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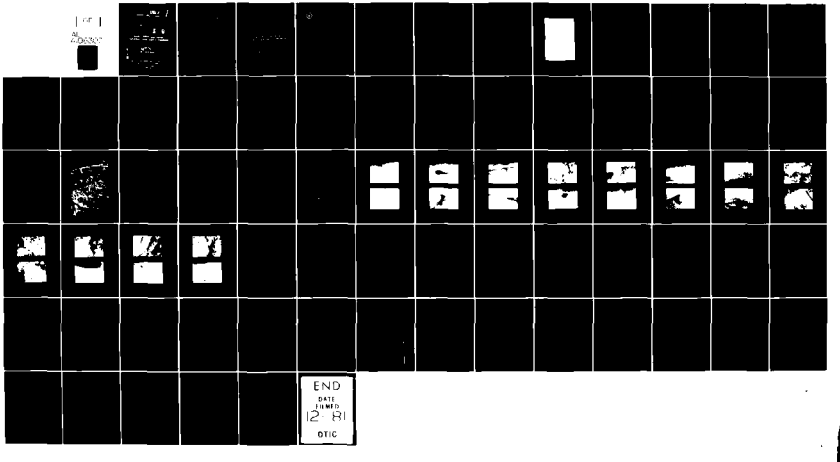

LEVEL II

MISSOURI-KANSAS CITY BASIN

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HOLT'S LAKE DAM
ST. LOUIS COUNTY, MISSOURI
MO 11106

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Rock Island
St. Louis District

DTIC FILE COPY

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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National Dam Safety Program. Holt's Lake Dam (MO 11105), Missouri - Kansas City Basin, St. Louis County, Missouri. Phase I Inspection Report.

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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HOLT'S LAKE DAM
ST. LOUIS COUNTY, MISSOURI
MO 11105

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

NOVEMBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Holt's Lake Dam (MO 11105).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — 7 MAY 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 11 MAY 1981
Colonel, CE, District Engineer — Date

HOLT'S LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11105

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

NOVEMBER 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Holt's Lake Dam
State Located	Missouri
County Located	St. Louis County
Stream	Tributary to Caulks Creek
Date of Inspection	18 November 1980

Holt's Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, a railroad, and a highway (CC). Contents of the estimated downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 15 percent of the probable maximum flood. The spillway will pass the flood which has a one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in satisfactory condition. Deficiencies visually observed by the inspection team were erosion on the downstream left and right interfaces between the embankment and abutments, erosion on the upstream right embankment-abutment interface, and an upslope road cut on upstream face which is

beginning to slough. Other deficiencies observed include trees on both slopes of the embankment, animal burrows on both slopes, erosion in the area of the spillway's inlet and outlet, and an eroded ditch near the toe of the dam. Seepage and stability analyses required by the guidelines were not available.

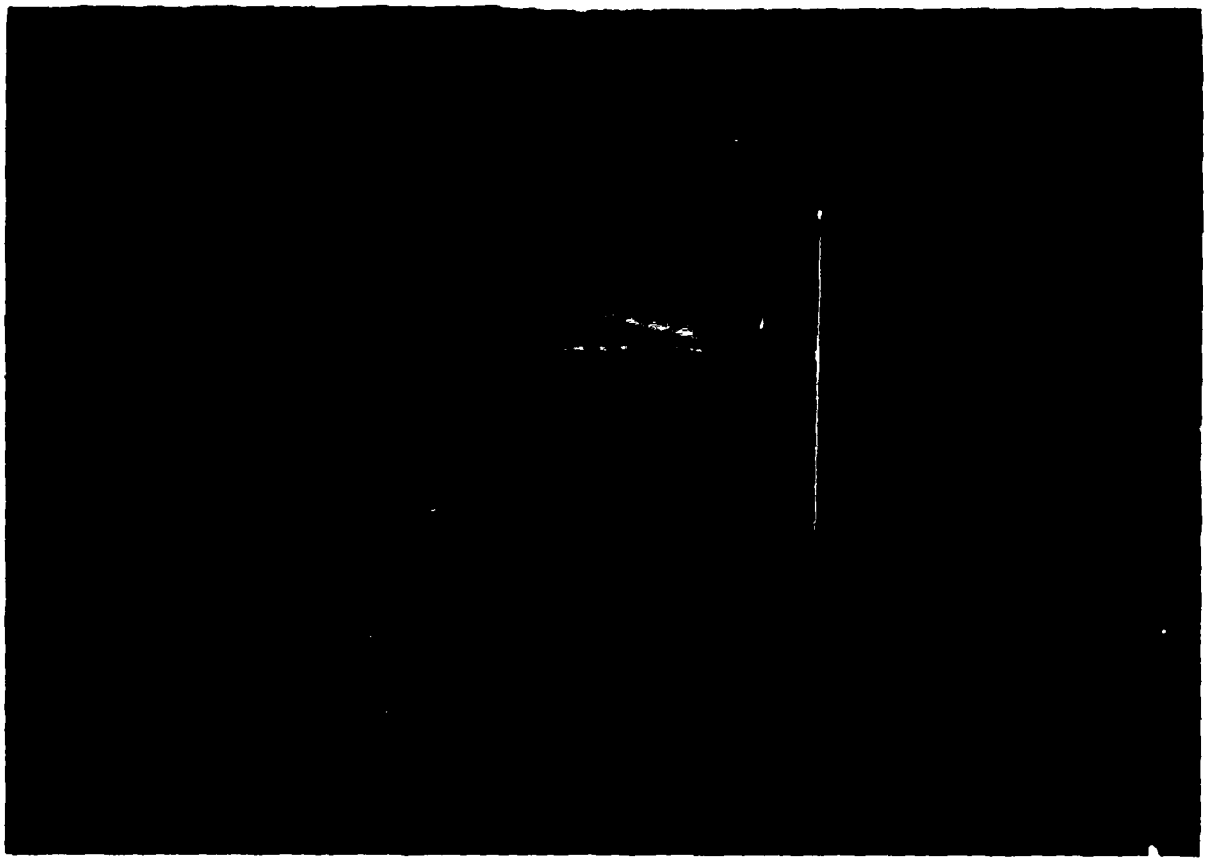
There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

Edwin R Burton

Edwin R. Burton, PE
Missouri E-10137

Harry L Callahan

Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HOLT'S LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Holt's Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary of Caulks Creek (see Plate 1). The watershed is an area of low hills with relatively steep slopes consisting of about 10 percent urban development and 90 percent wooded land. The dam is approximately [illegible] feet long along the crest and 47 feet high. The dam crest is about [illegible] feet wide. A 22-foot wide asphaltic pavement road is located along the crest of the dam. The upstream slope of the embankment varies from [illegible] to [illegible] feet horizontal to 1-foot vertical. The downstream slope ranges from 2.6 to 3.9 feet horizontal to 1-foot vertical.

(2) The spillway is a 30-inch diameter corrugated metal pipe which is reported to have concrete collars. The spillway is located near the left end of the dam and discharges to a concrete chute on the downstream slope of the dam. Left and right are used herein to define direction while facing downstream. The flow from the chute is directed to an [illegible]ined ditch and is uncontrolled.

Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in westcentral St. Louis County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Chesterfield, Missouri, in Section 17 of T45N, R04E.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the intermediate size category. An intermediate size dam is classified as having a height less than 100 feet, but greater than or equal to 40 feet and/or a storage capacity less than 50,000 acre-feet, but greater than or equal to 1,000 acre-feet.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: Holt's Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For Holt's Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, a railroad, and one highway (CC). Contents of the estimated downstream damage zone were verified by the inspection team.

e. Ownership. The dam is owned by the Chesterfield Lakes Homeowner's Association, % Mr. William Roberts, 1516 Chesterfield, Chesterfield, Mo. 63017.

f. Purpose of Dam. The dam will form a 14.5-acre lake used for recreation.

g. Design and Construction History. Data relating to the design and construction were not available. According to the developer, Burton-Duenke Construction Company, the dam was constructed in 1973.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and overflow through the uncontrolled spillway would all combine to maintain a relatively stable water surface elevation. The reservoir pool has not reached the spillway elevation since completion of the dam.

1.3 PERTINENT DATA

a. Drainage Area - 259 acres

b. Discharge at Damsite.

(1) Discharge at the damsite is through a 30-inch diameter corrugated metal pipe

(2) Estimated experienced maximum flood at damsite - Unknown

(3) Estimated ungated spillway capacity at maximum pool elevation 5[illegible] cfs (Probable Maximum Flood Pool El 538 +)

b. Elevation (feet above m s l) Approximate Tie to USGS Map

(1) Top of dam - 535.8 (see Plate 3)

(2) Spillway invert - 530.0

(3) Streambed at toe of dam - +489 (

(4) Maximum tailwater - Unknown

c. Reservoir

(1) Length of maximum pool - [illegible],650 feet + Probable maximum flood pool level

(2) Length of normal pool - [illegible],000 feet + Spillway invert

d. Storage (Acre-feet)

(1) Top of dam - [illegible]

(2) Spillway invert - [illegible]

(3) Design surcharge - Not available

e. Reservoir Surface (Acres)

(1) Top of dam - [illegible]

(2) Spillway invert - [illegible]

f. Dam

(1) Type - Earth embankment

(2) Length - [illegible]0 feet

(3) Height - [illegible] feet +

- Top width - [illegible] feet (crowned)

- Side slopes - upstream face between 1.0 V on 2.7 H and 1.0 V on [illegible] H, downstream face between 1.0 V on 1.8 H and 1.0 V on 2.9 H (see Plate [illegible]

- Zoning - Unknown

- Impervious core - Unknown

- Cutoff - Unknown

- Grout curtain - Unknown

Diversion and Regulating Tunnel - None

Spillway

- Type - [illegible]-inch diameter corrugated metal pipe

- Inlet invert elevation - 530.0 feet m.s.l.

- Outlet invert elevation - 528.[illegible] feet m.s.l.

- Gates - None

- Upstream channel - None

- Downstream channel - Discharges to a concrete chute and then [illegible] unlined ditch at the dam's toe

Emergency Spillway - None

- Regulating Outlets - None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The dam was designed by the firm of Volz Engineering and Surveying, Inc. They provided hydrologic and hydraulic calculations for the spillway, a contour map of the dam and reservoir site, and a report on grouting operations.

2.2 CONSTRUCTION

Construction records were unavailable. According to the developer, Burton-Duenke Construction Co., the dam was constructed in 1973.

2.3 OPERATION

Operational records and documentation of past floods were unavailable

2.4 GEOLOGY

The site of the dam and reservoir is located in a moderately-deep steep-sided valley between two ridges. The dam impounds a small, intermittent, tributary of Caulk's Creek

Published information was not available on the soils in the area of the dam and reservoir. The bedrock consists of limestone of the Burlington formation of the Osage Series of the Mississippian System. According to the letter in Appendix B, the reservoir is seeping through a zone of weakness that extends beneath the reservoir parallel and upstream of the dam. The seepage travels through a horizontal feeder system and exits at a spring located at Caulk's Creek. The Contractor has attempted to grout these horizontal feeders, and the grouting has apparently decreased the seepage. Additional grouting may be done if seepage quantities increase after the reservoir is filled. Since the seepage is through the bedrock, it should not present a hazard to the embankment

2.5 EVALUATION

a. Availability. Some engineering data were available. Representatives of both the design engineer and construction company were present during the inspection and answered questions

b. Adequacy. Engineering data available included hydrologic hydraulic calculations for the spillway, and storage-elevation curves. The hydrologic hydraulic design does not meet the criteria established by the guidelines. No embankment design or construction data were available, thus an assessment of the embankment design, construction, and operation

could not be made. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The spillway is designed to pass a 100-year 30-minute flood from a fully developed watershed. The design is valid but does not meet the requirements of the Guidelines. The validity of the embankment design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Holt's Lake Dam was made on 18 November 1980. The inspection team consisted of Edwin Burton, team leader, Robert Pinker, geologist, Gary Van Riessen, geotechnical engineer, and John Ruhl, hydraulic/ hydrologic engineer. Messrs. J. Davies and J. Lasky representing the Burton-Duenke Construction Company, and Mr. G. Borgard representing Volz Engineering and Surveying, Inc., accompanied the inspection team. The dam appeared to be in satisfactory condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracking, sliding, sloughing or other signs of settlement or instability were observed except at the gravel road down the upstream embankment slope. The upstream and downstream slopes of the embankment have some tree cover. No instruments to measure the performance of the dam were located. No toe drains or relief wells were observed although there is a ditch below the dam's toe which could serve as a drain.

The dam crest has a 22-foot wide asphaltic pavement road along its entire length which is broken in places. This damage is believed to be either the result of poor or the lack of adequate subgrade material.

There is a road cut down the upstream embankment slope. This road was built to accommodate access to the pool area for grouting work. The road cut shows signs of sloughing. Some cracking was observed at this cut.

Some erosion gullies were observed around the inlet and outlet of the spillway pipe. Erosion has also occurred on the upstream face at the right abutment-embankment interface below the outlet of the drain pipe under Holt's Lake Drive.

No evidence was found to indicate that the embankment had ever been overtopped. The reservoir has never been filled due to leakage through geologic faults in the pool area.

There was evidence that a maintenance program was in effect. A few animal burrows were observed on the embankment.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The spillway is a 30-inch corrugated metal pipe located near the left end of the dam.

There was erosion around the spillway inlet and outlet. The spillway pipe was considered to be in good condition. There is a slight deformation of the pipe and a slight dog leg alinement near the outlet. It should be noted that an abnormally large spillway discharge would probably damage the downstream slope.

There was no development in the spillway area which would suffer damage due to flow through the spillway.

d. Geology. The soils along the ridges and slopes of the reservoir are developed in loess and in residuum from the limestone bedrock. The loess is light brown in color and consists of silt and clay. For engineering purposes it is classified visually as a clayey silt of low plasticity. The residuum is dark reddish brown in color and consists of silt clay and chert fragments. For engineering purposes the soils are classified visually as silty clay of low plasticity with chert fragments. Soils developed in colluvium are present in the downstream valley. These soils are dark brown in color and consist of silt and clay. For engineering purposes the soils are classified visually as silty clay and clayey silt of low plasticity. No outcrops of bedrock were observed. Appendix B indicates rock is present near the bottom of the reservoir, and the existence of ridges indicates rock is present beneath them. The thickness of the overburden on the hills and in the valley is not known. No construction drawings or boring data were available. Evidence of grouting operations were observed along the left side of the hill and the shore of the reservoir.

Samples of the embankment material were taken near the center of the downstream crest using an Oakfield sampler. The soil samples were classified visually. Based on these samples, it is anticipated the embankment consists of clayey silt of low plasticity. The Contractor stated the core consists of clay.

e. Reservoir Area. No slumping or slides of the reservoir banks were observed. The upstream channel to the lake contains some minor debris and a few trees. The lake was noted to be clean with no siltation.

f. Downstream Channel. The spillway discharges to a concrete chute and then to an unlined ditch. The unlined ditch discharges to the natural channel downstream from the dam.

1.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control.

The growth of trees if allowed to go unchecked, could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass.

Burrowing animals will continue to damage the embankment if a control program is not undertaken. Piping failure of embankments has resulted from damages caused by burrowing animals.

A gravel road starting at about station 2 + 90 on the crest and proceeding laterally to about station 3 + 90 before cutting into the upstream embankment slope has been a contributing factor to erosion. Upon completion of the grouting work in the reservoir pool area, this road cut should be restored to designed conditions. Gravel, debris, etc. found in this area should be removed before the cut is backfilled and compacted.

The road pavement on the crest should be repaired in those areas where it has broken.

No seepage problems were observed at this dam. However, problems have occurred with leakage from the reservoir pool through geologic faults. Close monitoring of the embankment should be maintained during the reservoir filling process following sealing by grout of geologic faults.

The absence of riprap on the upstream slope has not led to any problems because of the lack of an appreciable reservoir pool. Riprap protection should be provided to reduce the potential for wave induced erosion.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool level will be primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled spillway once the lake is filled.

4.2 MAINTENANCE OF DAM

There was evidence that a maintenance program was in effect at the time of inspection. The grass cover along the crest has been mowed. Trees, however, were observed growing on the embankment.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

The maintenance program should be continued and should include in addition to mowing the grass cover on the embankment a task for replacing broken pavement along the crest. Procedures for controlling tree growth should be formulated with the assistance of an engineer experienced in earthen dam maintenance.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data were made available. Included were hydraulic calculations for the 30-inch spillway pipe and storage-elevation curves.

b. Experience Data. The drainage area and lake surface area are developed from USGS Chesterfield, Mo. quadrangle map. The dam layout is from a survey made during the inspection and a plat map provided by the engineer.

c. Visual Observations.

(1) The spillway appears to be in good condition. The lake level at the time of the inspection (El. 507.6) was below the spillway pipe inlet. There were no obstructions to flow in the downstream channel.

(2) Spillway discharges could endanger the integrity of t dam.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 15 percent of the probable maximum flood without overtopping the dam. The spillway will pass the one percent chance flood estimated to have a peak outflow of 40 cfs developed from a 48-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of intermediate size should pass 100 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,230 cfs of the total discharge from the reservoir of 2,290 cfs. The estimated duration of overtopping is 12.0 hours with a maximum height of 2.6 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 1,050 cfs of a total discharge of 1,100 cfs. The estimated duration of overtopping is 9.0 hours with a maximum height of 1.8 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. Four dwellings, a railroad, and a highway (CC) are located within the estimated damage zone, and lives could be lost should failure of the dam occur. Contents of the estimated downstream damage zone were verified by the inspection team. Flood plain regulations under the

National Flood Insurance Program restrict development in the flood plain of Caulks Creek which is downstream of Holt's Lake Dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. It is not known whether or not any changes have been made to the dam subsequent to its construction. There is an ongoing grouting program in the reservoir pool area.

e. Seismic Stability. The dam is located in Seismic Zone 2 which is a zone of moderate seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and or controlled. These are erosion on the downstream left and right interfaces between the embankment and abutments, erosion on the upstream right embankment-abutment interface, an upslope road cut on upstream face which is beginning to slough, trees on both slopes, animal burrows, erosion in the area of the spillway's inlet and outlet and erosion in a ditch near the toe of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the absence of engineering design data, the conclusions in this report were based only on performance history, visual conditions and general information obtained during the inspection from the developer. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 2. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

REMEDIAL MEASURES

a. Alternatives. Spillway capacity and/or storage volume would need to be increased or the lake level would need to be permanently lowered to increase available flood storage in order to effectively pass the spillway design flood. Spillway capacity could be increased by providing an emergency spillway. The storage volume could be increased by raising the dam crest.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be carried out under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams.

(1) Erosion protection should be placed on the upstream face of the dam to an elevation above normal lake level to prevent erosion of the embankment material. Paved ditches or other slope protection may be required to control the concentrated runoff at the abutment-embankment interface. The erosion around the inlet and outlet of the spillway pipe should be repaired and adequate protection provided.

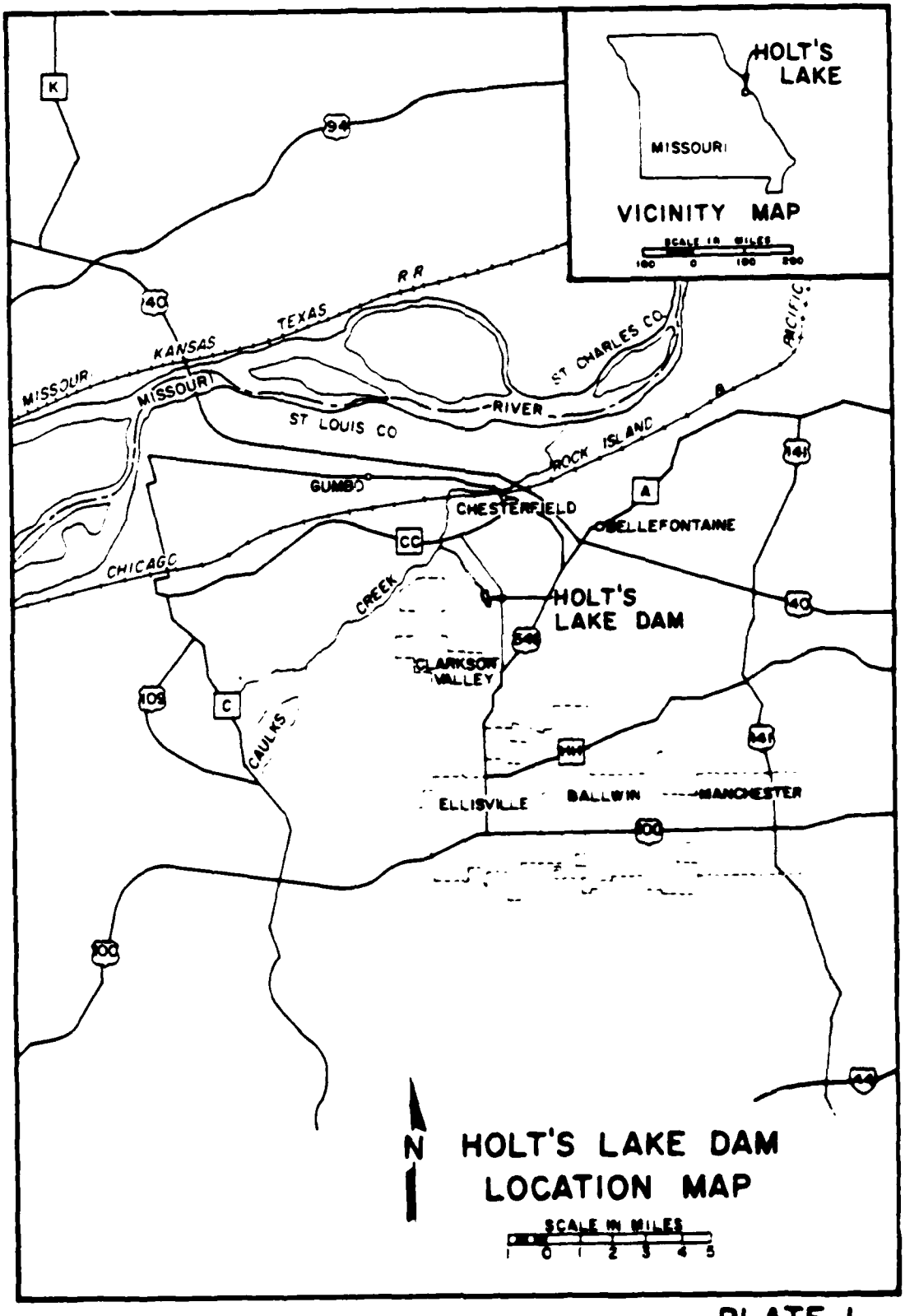
(2) A maintenance program should be formulated and implemented to remove and control the growth of trees on the embankment. Grass/ weed cover on the embankments should be cut periodically.

(3) The road cut on the upstream slope should be backfilled with suitable material and compacted upon completion of the grouting program.

(4) The animal burrows in the embankment should be corrected since they can contribute to the occurrence of piping. Control measures should be implemented to discourage animal activity in the area. The embankment slope should be monitored by a qualified engineer during repair of the embankment.

(5) Seepage and stability analyses should be performed.

(6) A detailed inspection of the dam should be made periodically and findings of the inspections should be documented and made a matter of record. More frequent inspections should be performed during the reservoir filling process to ascertain that leakage, seepage, slope instability, etc. do not occur undetected. If these types of problems occur, an engineer experienced in earth dams should be engaged to assist in formulating corrective measures.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340
CLARKSON VALLEY
109
C
CAULKS
141
ELLISVILLE
BALLWIN
MANCHESTER
50
44
N
HOLT'S LAKE DAM
LOCATION MAP
SCALE IN MILES
1 0 1 2 3 4 5

PLATE I


OLIVE STREET ROAD
3 LANE
Gumbo
St Thomas Ch
LEVEE
LEVEE
Chesterfield
HOLT'S LAKE
WATERSHED AREA
N
HOLT'S LAKE DAM
VICINITY TOPOGRAPHY
SCALE IN FEET

PLATE 2

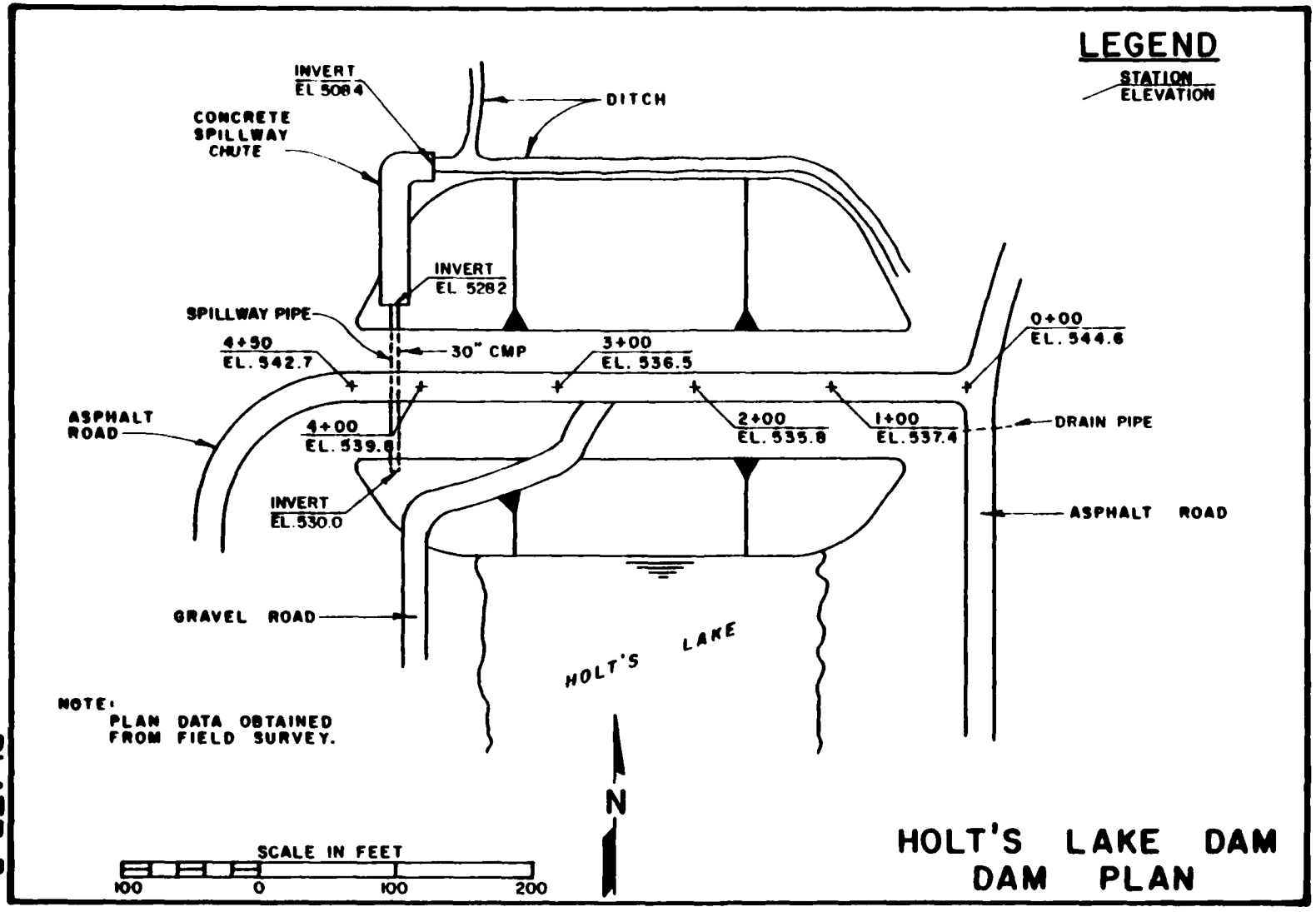

LEGEND
STATION
ELEVATION
INVERT
EL 5084
DITCH
CONCRETE
SPILLWAY
CHUTE
INVERT
EL 5282
SPILLWAY PIPE
30" CMP
4+50
EL. 542.7
3+00
EL. 536.5
0+00
EL. 544.6
ASPHALT
ROAD
4+00
EL. 539.8
2+00
EL. 535.8
1+00
EL. 537.4
DRAIN PIPE
INVERT
EL. 530.0
ASPHALT ROAD
GRAVEL ROAD
HOLT'S LAKE
NOTE:
PLAN DATA OBTAINED
FROM FIELD SURVEY.
N
SCALE IN FEET
100
0
100
200
HOLT'S LAKE DAM
DAM PLAN

PLATE 3

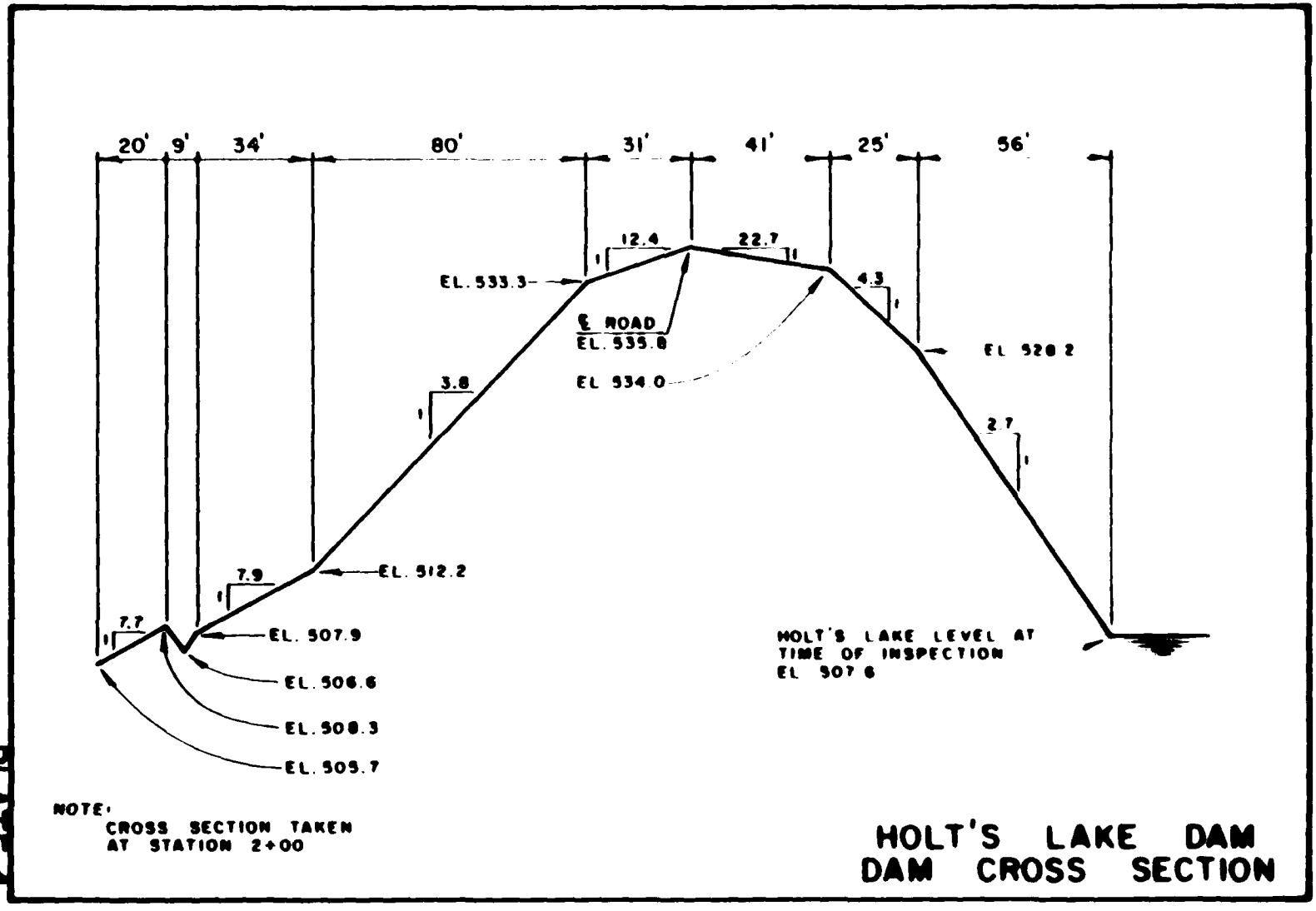

20'
9'
34'
80'
31'
41'
25'
56'
12.4
22.7
EL. 533.3
4.3
℄ ROAD
EL. 535.8
EL 534.0
EL 528.2
3.8
2.7
7.9
EL. 512.2
7.7
EL. 507.9
EL. 506.6
EL. 508.3
EL. 505.7
HOLT'S LAKE LEVEL AT
TIME OF INSPECTION
EL 507.6
NOTE:
CROSS SECTION TAKEN
AT STATION 2+00
HOLT'S LAKE DAM
DAM CROSS SECTION

PLATE 4

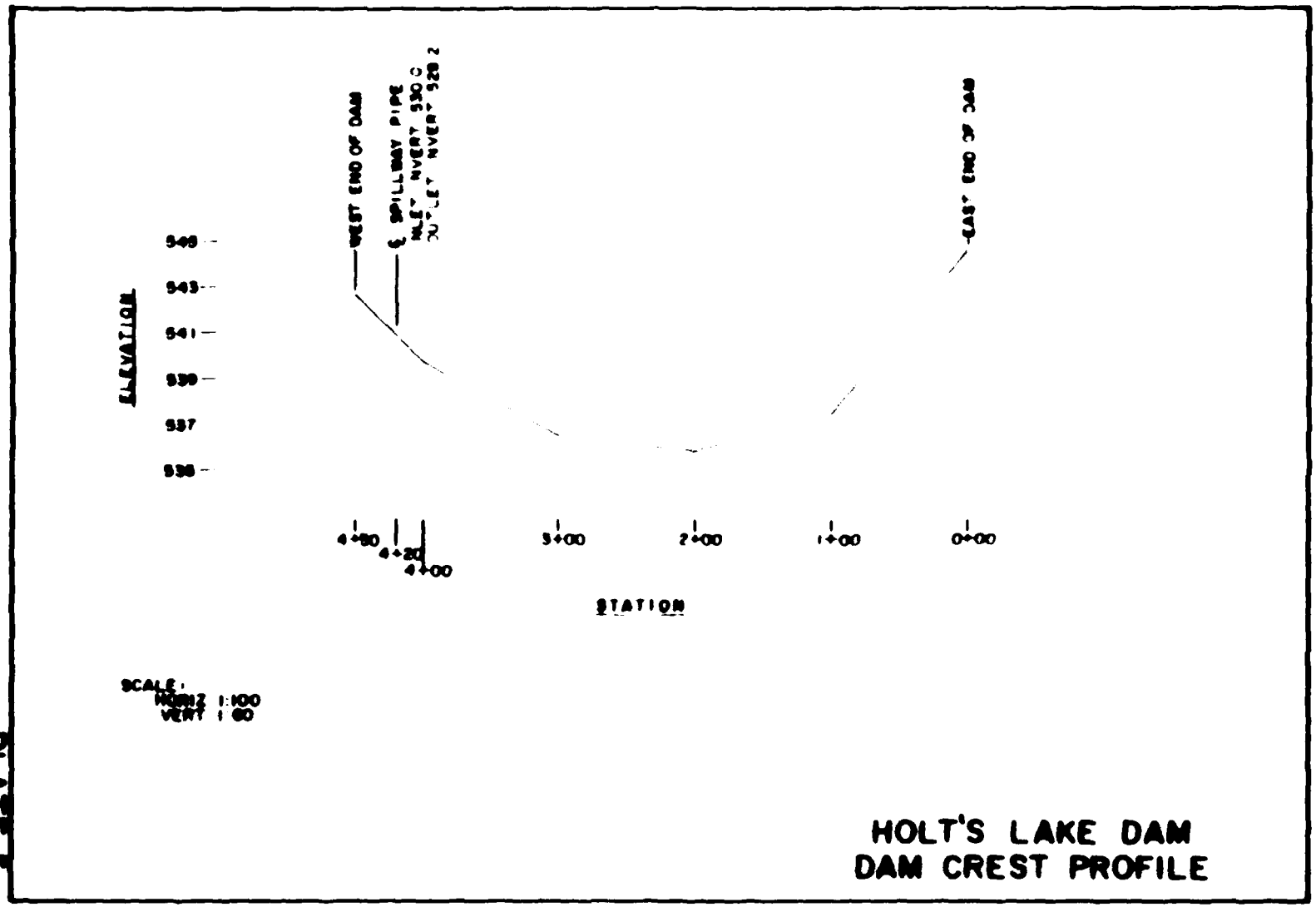


PLATE 5

HOLT'S LAKE DAM
DAM CREST PROFILE

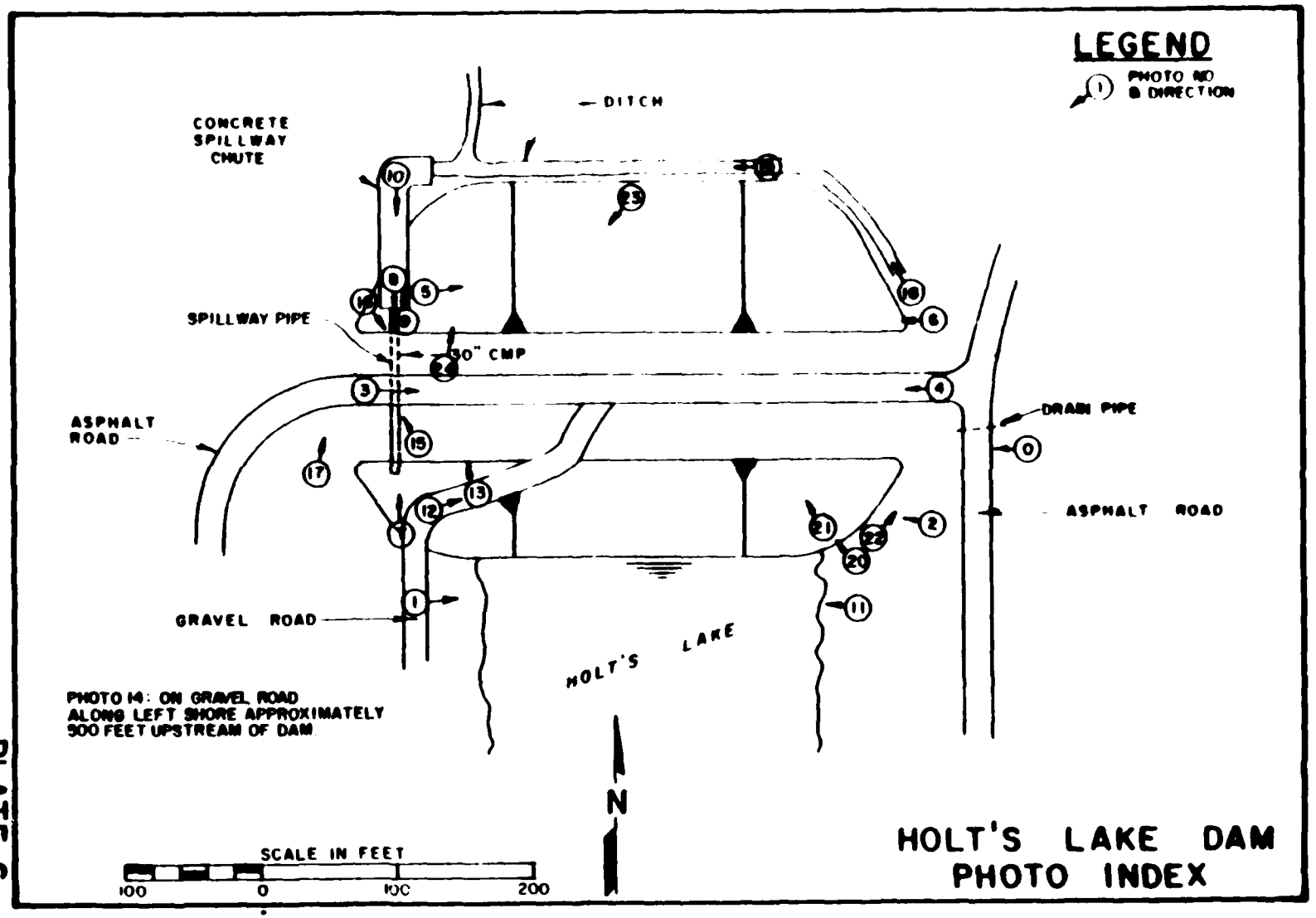

LEGEND
PHOTO NO & DIRECTION
DITCH
CONCRETE SPILLWAY CHUTE
SPILLWAY PIPE
30" CMP
ASPHALT ROAD
DRAIN PIPE
ASPHALT ROAD
GRAVEL ROAD
HOLT'S LAKE
PHOTO 14: ON GRAVEL ROAD ALONG LEFT SHORE APPROXIMATELY 500 FEET UPSTREAM OF DAM
SCALE IN FEET
100 0 100 200
N
HOLT'S LAKE DAM
PHOTO INDEX

PLATE 6

PHOTO 1: UPSTREAM FACE OF DAM

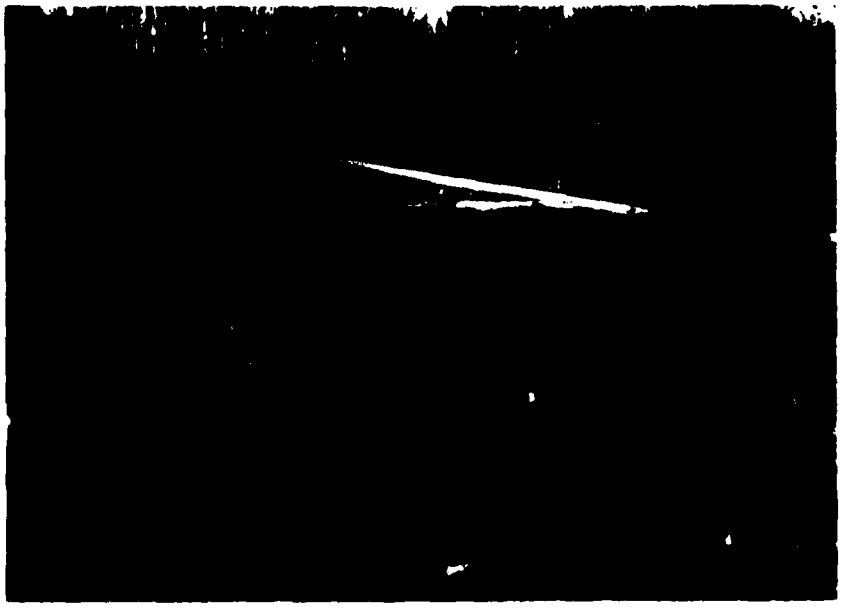


PHOTO 2: UPSTREAM FACE OF DAM LOOKING WEST

PHOTO 3: CREST OF DAM

PHOTO 4: CREST OF DAM LOOKING WEST

PHOTO 5: DOWNSTREAM FACE OF DAM

PHOTO 6: DOWNSTREAM FACE OF DAM LOOKING WEST

PHOTO 7: INLET END SPILLWAY PIPE

PHOTO 8: OUTLET END SPILLWAY PIPE

PHOTO 9: CONCRETE CHUTE DOWNSTREAM OF SPILLWAY PIPE

PHOTO 10: CONCRETE CHUTE LOOKING UPSTREAM

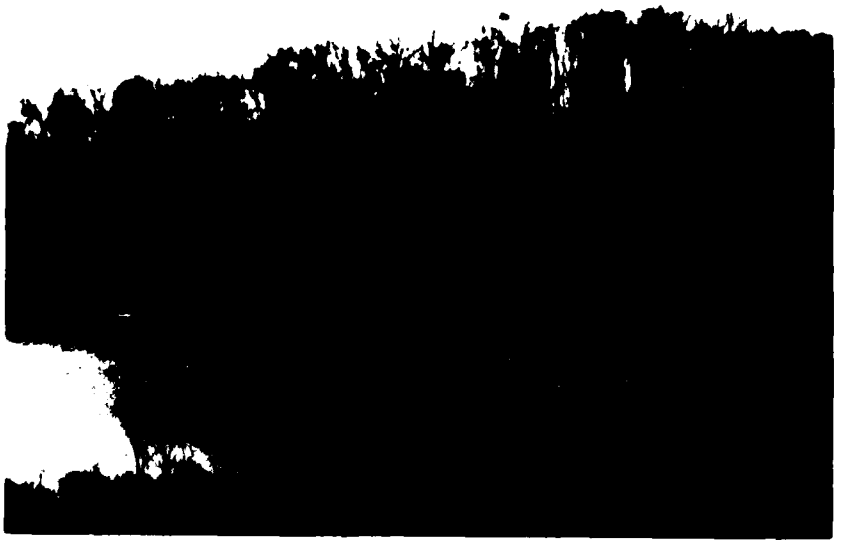


PHOTO 11: OVERVIEW OF CONSTRUCTION ROAD

PHOTO 12: CONSTRUCTION ROAD ON UPSTREAM FACE OF DAM

PHOTO 13: CONSTRUCTION ROAD CUT ON UPSTREAM FACE

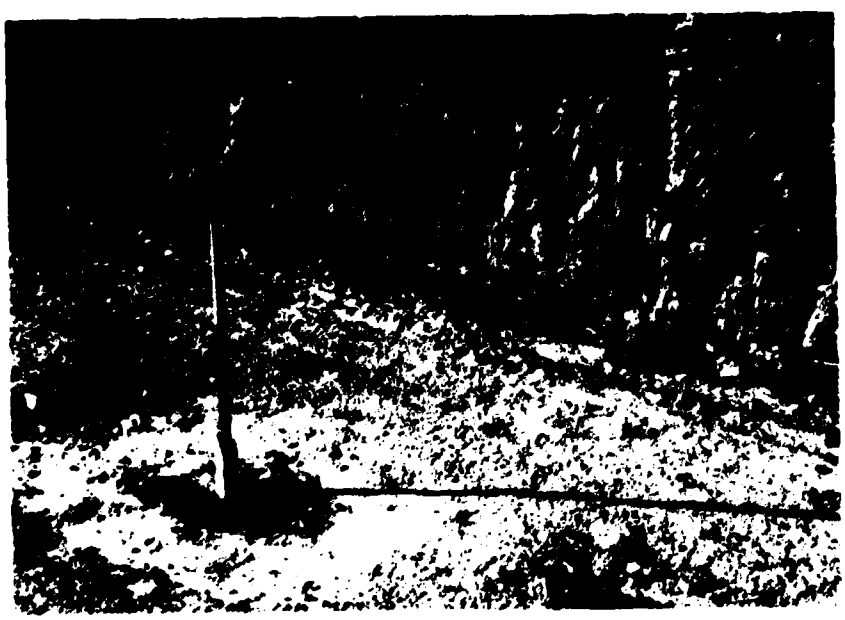


PHOTO 14: GROUT HOLE IN CONSTRUCTION ROAD

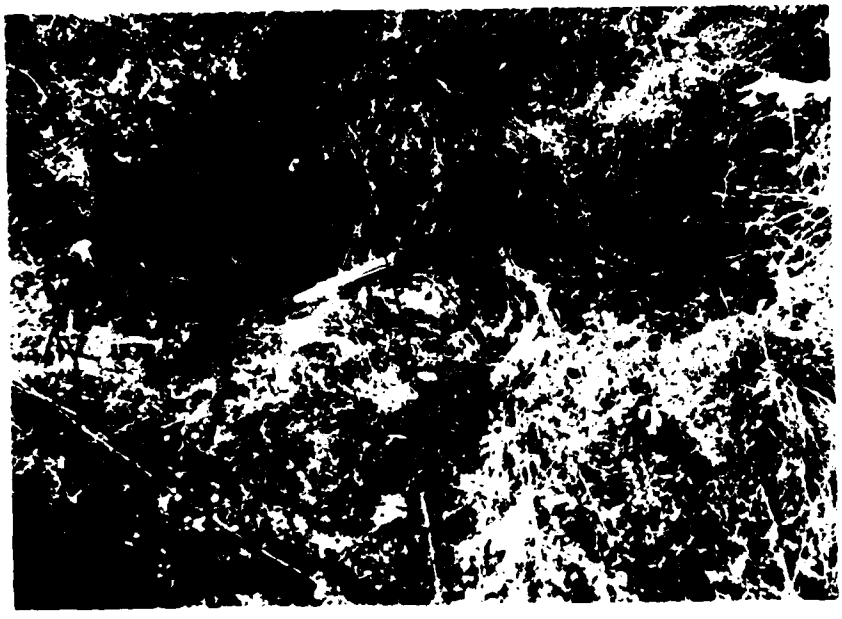


PHOTO 15: EROSION OF UPSTREAM FACE ABOVE SPILLWAY PIPE

PHOTO 16: UNDERCUTTING OF SPILLWAY PIPE NEAR OUTLET

PHOTO 17: EROSION OF UPSTREAM FACE AT LEFT ABUTMENT

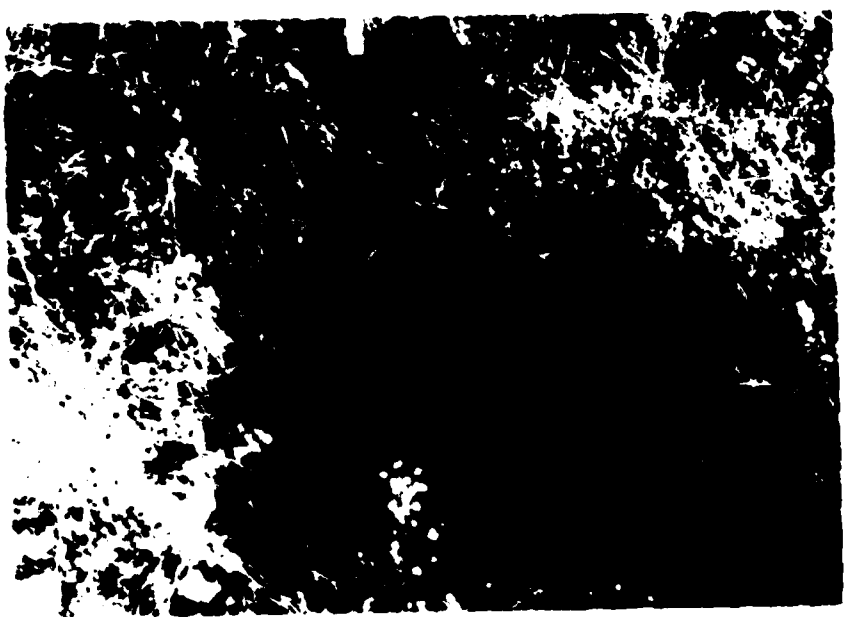


PHOTO 18: EROSION OF DOWNSTREAM FACE AT RIGHT ABUTMENT

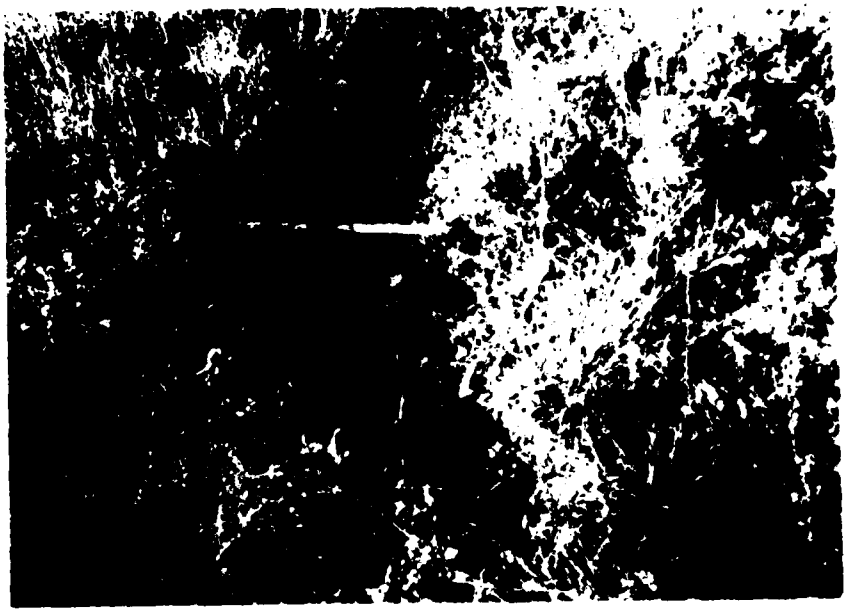
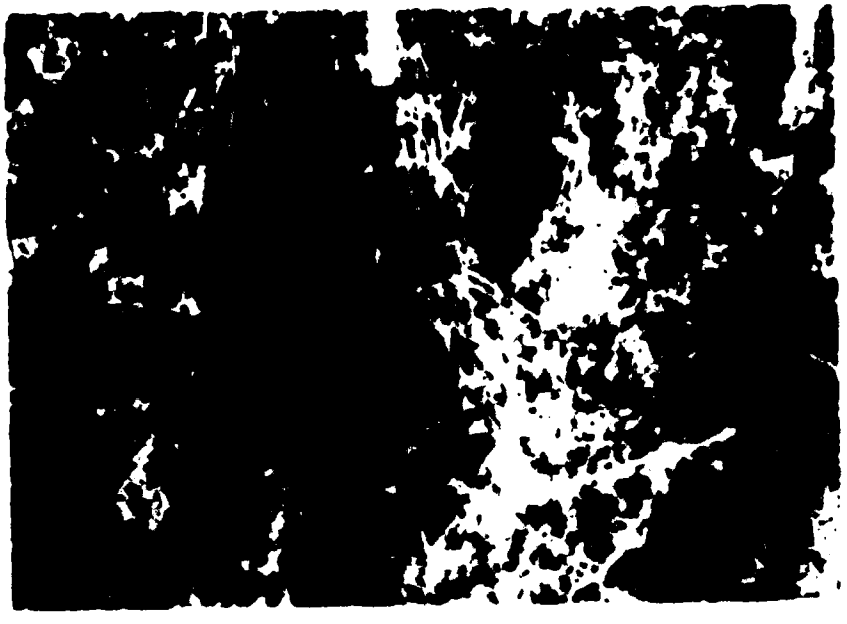


PHOTO 19: EROSION OF DOWNSTREAM TOE OF SLOPE

PHOTO 20: OVERVIEW OF EROSION OF UPSTREAM FACE NEAR RIGHT END

PHOTO 21: CLOSE-UP OF EROSION OF UPSTREAM FACE NEAR RIGHT END

PHOTO 22: EROSION AND RIPRAP BELOW DRAIN PIPE RIGHT ABUTMENT



APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was determined using the computer program HEC-1 (Dam Safety Version).

The PMP was determined from regional charts prepared by the National Weather Service in Hydrometeorological Report No. 33 (HMR-33). No reduction factors were not applied. The rainfall distribution for the 96-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The St. Louis, Missouri rainfall distribution (5 min. interval - 96 hours duration), as provided by the St. Louis District Corps of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillway.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Conservation Service (SCS) method [1,5]. The hydrograph lag time was calculated by the SCS curve number method. The value obtained was verified by the Kirpich formula. The parameters for the unit hydrograph are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for the rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2.

The reservoir routing was performed using the modified Puls method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the invert elevation of the spillway pipe at elevation 530.0 feet m.s.l. in accordance with antecedent storm conditions AMC II, and AMC III preceding the one percent probability and probable maximum storms respectively, as outlined by the U.S. Army Corps of Engineers, St. Louis District [4]. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillway is shown in Table 4. Spillway discharges are based on a pipe culvert flowing under inlet control [6]. The flow over the crest of the dam was determined using the non-level dam crest option (SI and SV cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

The result of the routing analysis indicates that the spillway will pass a flood equivalent to 33 percent of the PMP without overtopping the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table [illegible].

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters

Drainage Area (A)	259 acres	
Hydraulic Length of watercourse (L)	5,240 feet	
Hydrologic Soil cover complex Number (CN)	85 (AMC III)	70 (AMC II)
Average watershed Land Slope (Y)	2.4%	
Lag time (t_g)	0.65 hours (AMC III)	1.0 hours (AMC II)
Time of concentration (T_c)	1.1 hours (AMC III)	1.7 hours (AMC II)
Duration (D)	9 min. (AMC III) (use 10 minutes in each case)	13 min. (AMC II)

Time (Min.)	Discharge (cfs) * AMC II	AMC III
0	0	0
10	12	33
20	36	105
30	73	208
40	122	261
50	160	255
60	177	213
70	177	150
80	162	100
90	141	69
100	113	49
110	83	33
120	65	23

* From HEC-1 computer output

TABLE 1 (Continued)

FORMULAS USED

$$I_g = \frac{0.8 \times (S + 1)^{0.7}}{1,900 \times V^{0.5}} \qquad (7)$$

$$S = \frac{1000}{CN} - 10$$

$$T_c = I_g / 0.6$$

$$D = 0.133\ T_c$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	48	35.28	33.25	2.03
1% Probability	48	8.78	5.14	3.64

Additional Data:

1) No information on soil associations was available for this watershed.
   100 percent of drainage area is hydrologic soil Group C
   90 percent of the land use was timberland
   10 percent of the land use was urban development
2) SCS Runoff Curve CN = 85 (AMC III) for the PMF.
3) SCS Runoff Curve CN = 70 (AMC II) for the one percent probability flood.

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
*530.0	14.5	226	0
**535.8	20.5	327	43
***538.4	23.2	382	54

*Spillway Crest Elevation
**Top of Dam Elevation
***PMF Pool Level

The relationships in Table 3 were developed from the Chesterfield, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (ft)	Spillway Discharge (cfs)
*530.0	0
532.0	14
534.0	33
**535.8	43
538.0	53
540.0	60

*Spillway Crest Elevation
**Top of Dam Elevation

METHOD USED:

Spillway release rates are based on nomographs for a pipe culvert with inlet control (6).

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam	Duration Over Top of Dam (Hrs.)
-	0	*530.0	92	0	-	-
0.15	363	535.0	311	39	0	-
0.50	1,210	537.6	364	1,100	1.8	9.0
1.00	2,420	538.4	382	2,290	2.6	12.0

* Spillway crest elevation

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Modification April 1980, Davis, California.

(2) HMR 33, Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations from 6 to 48 Hours, U.S. Department of Commerce, NOAA, National Weather Service, 1956.

(3) EM-1110-2-1411, Standard Project Flood Determinations, U.S. Army Corps of Engineers, 26 March 1952.

(4) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/ Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 22 August 1980.

(5) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(6) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Charts For The Selection Of Highway Culverts, December 1965.

(7) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
A1      MISSOURI DAM INSPECTIONS
A2      HOLT'S LAKE
A3      PMF AND RATIOS
B    288      0     10      0      0      0      0      0      0      0
B1     5
J      1      9      1
J10.1  0.15    0.2   0.25    0.3   0.35    0.4    0.5    1.0
K           HEAD                                    1
K1      CALCULATE INFLOW HYDROGRAPH TO LAKE
M      1   20.4                    1.
P   25.2   101.   120.   130.   140.
T                                              -1-05.
W2  0.65
X                1.
K      1    DAM                                     1
K1      ROUTE HYDROGRAPHS PAST DAM
Y                            1      1
Y1     1                                   -530.         -1
Y4530.  531.   532.   533.   534.  535.8   536.   540.   545.   550.
Y50.     5.    14.    26.    33.    43.    53.    60.    77.    90.
$A0.    3.1    8.0   14.5   24.9   35.3   47.7
$E492.  500.   520.   530.   540.   550.   560.
$S530.
$D535.8
$L0.    50.   147.   250.   332.   366.   427.   480.
$V535.7 535.8 536.4  537.6  539.4  540.4  542.7   545.
K     99
A
A
A
A
A
```

B L A C K   &   V E A T C H   PROJECT 9166:   DATE 29 JAN 81   PAGE
FLOOD HYDROGRAPH PACKAGE - HEC-1   PROGRAM H21/02-1V TIME 09:55:01   CASE

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	HEAD
ROUTE HYDROGRAPH TO	DAM
END OF NETWORK	

```
B L A C K   V E A T C H                                                    PROJECT [illegible]     DATE [illegible] JAN 8[illegible]  PAGE [illegible]
**********************************************************************************************************************
FLOOD HYDROGRAPH PACKAGE - HEC-1                                           PROGRAM H21/02-IV  TIME 09:[illegible]  CASE

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
                          MISSOURI DAM INSPECTIONS
                          HOLT'S LAKE
                          PMF AND RATIOS

                                     JOB SPECIFICATION
           NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
          288       0      10       0       0       0       0       0       0       0
                                  JOPER     NWT   LROPT   TRACE
                                      5       0       0       0

                             MULTI-PLAN ANALYSIS TO BE PERFORMED
                               NPLAN= 1 NRTIO= 9 LRTIO= 1
            RTIOS=   .10    .15    .20    .25    .30    .35    .40    .50   1.00

      *********          *********          *********          *********          *********

                                SUB-AREA RUNOFF COMPUTATION

                 CALCULATE INFLOW HYDROGRAPH TO LAKE

                        ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                         HEAD       0       0       0       0       0       1       0       0

                                     HYDROGRAPH DATA
           IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
               1      2     .49     .09     .49    1.00    .000       0       0       0

                                       PRECIP DATA
                     SPFE     PMS      R6     R12     R24     R48     R72     R96
                      .00   25.20  101.00  120.00  130.00  140.00     .00     .00

                                        LOSS DATA
        LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
            0     .00     .00    1.00     .00     .00    1.00   -1.00  -85.00     .00     .00

          CURVE NO =  -85.00  WETNESS =   -1.00  EFFECT CN =   85.00

                                    UNIT HYDROGRAPH DATA
                                TC=   .00    LAG=   .45

                                      RECESSION DATA
                           STRTQ=    .00   QRCSN=    .00   RTIOR= 1.00

           UNIT HYDROGRAPH 21 END OF PERIOD ORDINATES, TC=    .00 HOURS, LAG=   .45  VOL= 1.00
        33.      105.      208.      261.      255.      213.      150.      100.       69.       49.
        35.       25.       16.       11.        8.        5.        4.        3.        2.        1.
         1.

B L A C K  &  V E A T C H                                                  PROJECT [illegible]     DATE 29 JAN 8[illegible]   PAGE [illegible]
**********************************************************************************************************************
FLOOD HYDROGRAPH PACKAGE - HEC-1                                           PROGRAM H21/02-IV  TIME 09:55:[illegible]  CASE

                                    END-OF-PERIOD FLOW
```

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	0.	1.02	.10	145	.03	[illegible]	.01	5.
1.01	.20	2	.00	.00	.00	0.	1.02	.20	146	.03	[illegible]	[illegible]	[illegible]
1.01	.30	3	.00	.00	.00	0.	1.02	.30	147	.03	.02	.01	11.
1.01	.40	4	.00	.00	.00	0.	1.02	.40	148	.03	[illegible]	.01	16.
1.01	.50	5	.00	.00	.00	0.	1.02	.50	149	.03	.02	.01	21.
1.01	1.00	6	.00	.00	.00	0.	1.02	1.00	150	.03	.02	.01	[illegible]
1.01	1.10	7	.00	.00	.00	0.	1.02	1.10	151	.03	.02	.01	28.
1.01	1.20	8	.00	.00	.00	0.	1.02	1.20	152	.03	.02	.01	31.
1.01	1.30	9	.00	.00	.00	0.	1.02	1.30	153	.03	.02	.01	[illegible]
1.01	1.40	10	.00	.00	.00	0.	1.02	1.40	154	.03	.02	[illegible]	[illegible]
1.01	1.50	11	.00	.00	.00	0.	1.02	1.50	155	.03	[illegible]	[illegible]	[illegible]
1.01	2.00	12	.00	.00	.00	0.	1.02	2.00	156	.03	[illegible]	[illegible]	[illegible]
1.01	2.10	13	.00	.00	.00	0.	1.02	2.10	157	.03	.02	.01	[illegible]
1.01	2.20	14	.00	.00	.00	0.	1.02	2.20	158	.03	.02	.01	15.
1.01	2.30	15	.00	.00	.00	0.	1.02	2.30	159	.03	.02	[illegible]	15.
1.01	2.40	16	.00	.00	.00	0.	1.02	2.40	160	.03	.02	[illegible]	[illegible]
1.01	2.50	17	.00	.00	.00	0.	1.02	2.50	161	.03	.02	.01	[illegible]
1.01	3.00	18	.00	.00	.00	0.	1.02	3.00	162	.03	.02	[illegible]	[illegible]
1.01	3.10	19	.00	.00	.00	0.	1.02	3.10	163	.03	.02	.01	[illegible]
1.01	3.20	20	.00	.00	.00	0.	1.02	3.20	164	.03	.02	.01	[illegible]
1.01	3.30	21	.00	.00	.00	0.	1.02	3.30	165	.03	[illegible]	[illegible]	[illegible]
1.01	3.40	22	.00	.00	.00	0.	1.02	3.40	166	.03	[illegible]	[illegible]	[illegible]
1.01	3.50	23	.00	.00	.00	0.	1.02	3.50	167	.03	.02	.01	[illegible]
1.01	4.00	24	.00	.00	.00	0.	1.02	4.00	168	.03	.02	.01	17.
1.01	4.10	25	.00	.00	.00	0.	1.02	4.10	169	.03	.02	.01	17.
1.01	4.20	26	.00	.00	.00	0.	1.02	4.20	170	.03	.02	.01	17.
1.01	4.30	27	.00	.00	.00	0.	1.02	4.30	171	.03	.02	.01	[illegible]
1.01	4.40	28	.00	.00	.00	0.	1.02	4.40	172	.03	[illegible]	[illegible]	17.
1.01	4.50	29	.00	.00	.00	0.	1.02	4.50	173	.03	.02	.01	[illegible]
1.01	5.00	30	.00	.00	.00	0.	1.02	5.00	174	.03	.02	.01	17.
1.01	5.10	31	.00	.00	.00	0.	1.02	5.10	175	.03	.02	.01	17.
1.01	5.20	32	.00	.00	.00	0.	1.02	5.20	176	.03	.02	.01	17.
1.01	5.30	33	.00	.00	.00	0.	1.02	5.30	177	.03	.02	.01	17.
1.01	5.40	34	.00	.00	.00	0.	1.02	5.40	178	.03	.02	[illegible]	17.
1.01	5.50	35	.00	.00	.00	0.	1.02	5.50	179	.03	.02	.01	17.
1.01	6.00	36	.00	.00	.00	0.	1.02	6.00	180	.03	.02	.01	17.
1.01	6.10	37	.01	.00	.01	0.	1.02	6.10	181	.13	.12	.02	41.
1.01	6.20	38	.01	.00	.01	0.	1.02	6.20	182	.13	.12	.02	[illegible]
1.01	6.30	39	.01	.00	.01	0.	1.02	6.30	183	.13	.12	.01	[illegible]
1.01	6.40	40	.01	.00	.01	0.	1.02	6.40	184	.13	.12	.01	64.
1.01	6.50	41	.01	.00	.01	0.	1.02	6.50	185	.13	.12	.01	134.
1.01	7.00	42	.01	.00	.01	0.	1.02	7.00	186	.13	.12	.01	[illegible]
1.01	7.10	43	.01	.00	.01	0.	1.02	7.10	187	.13	.12	.01	155.
1.01	7.20	44	.01	.00	.01	0.	1.02	7.20	188	.13	.12	.01	[illegible]
1.01	7.30	45	.01	.00	.01	0.	1.02	7.30	189	.13	.12	.01	170.
1.01	7.40	46	.01	.00	.01	0.	1.02	7.40	190	.13	.12	.01	176.
1.01	7.50	47	.01	.00	.01	0.	1.02	7.50	191	.13	.12	.01	175.
1.01	8.00	48	.01	.00	.01	0.	1.02	8.00	192	.13	.12	.01	182.
1.01	8.10	49	.01	.00	.01	0.	1.02	8.10	193	.13	.12	.01	185.
1.01	8.20	50	.01	.00	.01	0.	1.02	8.20	194	.13	.12	.01	192.
1.01	8.30	51	.01	.00	.01	0.	1.02	8.30	195	.13	.12	.01	194.
1.01	8.40	52	.01	.00	.01	0.	1.02	8.40	196	.13	.12	.01	199.
1.01	8.50	53	.01	.00	.01	0.	1.02	8.50	197	.13	.12	.01	194.

1.01	9.00	54	.01	.00	.01	0.	1.02	9.00	198	.17	.15	.01	151.
1.01	9.10	55	.01	.00	.01	0.	1.02	9.10	199	.17	.15	.01	1[illegible]
1.01	9.20	56	.01	.00	.01	0.	1.02	9.20	200	.17	.15	.01	1[illegible]
1.01	9.30	57	.01	.00	.01	0.	1.02	9.30	201	.17	.15	.01	1[illegible]
1.01	9.40	58	.01	.00	.01	0.	1.02	9.40	202	.17	.15	.01	1[illegible]
1.01	9.50	59	.01	.00	.01	0.	1.02	9.50	203	.17	.15	.01	194.
1.01	10.00	60	.01	.00	.01	0.	1.02	10.00	204	.17	.15	.01	1[illegible]
1.01	10.10	61	.01	.00	.01	0.	1.02	10.10	205	.17	.15	.01	1[illegible]
1.01	10.20	62	.01	.00	.01	0.	1.02	10.20	206	.17	.15	.01	1[illegible]
1.01	10.30	63	.01	.00	.01	0.	1.02	10.30	207	.17	.15	.01	1[illegible]
1.01	10.40	64	.01	.00	.01	0.	1.02	10.40	208	.17	.15	.01	1[illegible]
1.01	10.50	65	.01	.00	.01	0.	1.02	10.50	209	.17	.15	.01	1[illegible]
1.01	11.00	66	.01	.00	.01	0.	1.02	11.00	210	.17	.15	.01	1[illegible]
1.01	11.10	67	.01	.00	.01	0.	1.02	11.10	211	.17	.15	.01	1[illegible]
1.01	11.20	68	.01	.00	.01	0.	1.02	11.20	212	.17	.15	.01	1[illegible]
1.01	11.30	69	.01	.00	.01	0.	1.02	11.30	213	.17	.15	.01	197.
1.01	11.40	70	.01	.00	.01	0.	1.02	11.40	214	.17	.15	.01	1[illegible]
1.01	11.50	71	.01	.00	.01	1.	1.02	11.50	215	.17	.15	.01	1[illegible]
1.01	12.00	72	.01	.00	.01	1.	1.02	12.00	216	.17	.15	.01	1[illegible]
1.01	12.10	73	.03	.00	.03	1.	1.02	12.10	217	.42	.41	.01	427.
1.01	12.20	74	.03	.00	.03	1.	1.02	12.20	218	.42	.41	.01	2[illegible]
1.01	12.30	75	.03	.01	.03	2.	1.02	12.30	219	.42	.41	.01	296.
1.01	12.40	76	.04	.01	.03	3.	1.02	12.40	220	.42	.41	.01	3[illegible]
1.01	12.50	77	.04	.01	.03	5.	1.02	12.50	221	.42	.41	.01	441.
1.01	13.00	78	.04	.01	.03	6.	1.02	13.00	222	.42	.41	.01	5[illegible]
1.01	13.10	79	.06	.01	.05	8.	1.02	13.10	223	.59	.58	.01	55[illegible]
1.01	13.20	80	.06	.01	.05	9.	1.02	13.20	224	.59	.58	.01	59[illegible]
1.01	13.30	81	.06	.01	.05	11.	1.02	13.30	225	.59	.58	.01	6[illegible]
1.01	13.40	82	.06	.01	.05	13.	1.02	13.40	226	.59	.58	.01	6[illegible]
1.01	13.50	83	.06	.01	.05	15.	1.02	13.50	227	.59	.58	.01	6[illegible]
1.01	14.00	84	.06	.02	.05	16.	1.02	14.00	228	.59	.58	.01	7[illegible]
1.01	14.10	85	.09	.02	.08	18.	1.02	14.10	229	.84	.83	.01	743.
1.01	14.20	86	.09	.02	.08	20.	1.02	14.20	230	.84	.83	.01	7[illegible]
1.01	14.30	87	.09	.02	.07	23.	1.02	14.30	231	.84	.83	.01	8[illegible]
1.01	14.40	88	.09	.02	.07	25.	1.02	14.40	232	.84	.83	.01	8[illegible]
1.01	14.50	89	.09	.02	.07	28.	1.02	14.50	233	.84	.83	.01	9[illegible]
1.01	15.00	90	.09	.03	.07	30.	1.02	15.00	234	.84	.83	.01	9[illegible]
1.01	15.10	91	.09	.02	.07	33.	1.02	15.10	235	.84	.83	.01	9[illegible]
1.01	15.20	92	.07	.04	.03	35.	1.02	15.20	236	.67	.66	.01	966.
1.01	15.30	93	.13	.08	.05	39.	1.02	15.30	237	1.26	1.25	.01	1[illegible]
1.01	15.40	94	.33	.22	.12	52.	1.02	15.40	238	4.35	4.23	.12	1[illegible]
1.01	15.50	95	.18	.07	.09	75.	1.02	15.50	239	1.26	1.25	.01	1[illegible]
1.01	16.00	96	.06	.04	.02	101.	1.02	16.00	240	.77	.77	.01	2[illegible]
1.01	16.10	97	.05	.03	.01	117.	1.02	16.10	241	.59	.59	.01	2[illegible]
1.01	16.20	98	.05	.03	.01	118.	1.02	16.20	242	.59	.59	.01	2[illegible]
1.01	16.30	99	.05	.03	.01	108.	1.02	16.30	243	.59	.59	.01	2[illegible]
1.01	16.40	100	.05	.03	.01	93.	1.02	16.40	244	.59	.59	.01	1[illegible]
1.01	16.50	101	.05	.03	.01	80.	1.02	16.50	245	.59	.59	.01	1[illegible]
1.01	17.00	102	.05	.03	.01	71.	1.02	17.00	246	.59	.59	.01	1[illegible]
1.01	17.10	103	.04	.03	.01	66.	1.02	17.10	247	.47	.47	.01	1[illegible]
1.01	17.20	104	.04	.03	.01	61.	1.02	17.20	248	.47	.47	.01	1[illegible]
1.01	17.30	105	.04	.03	.01	57.	1.02	17.30	249	.47	.47	.01	1[illegible]
1.01	17.40	106	.04	.03	.01	53.	1.02	17.40	250	.47	.47	.00	9[illegible]
1.01	17.50	107	.04	.03	.01	50.	1.02	17.50	251	.47	.47	.00	8[illegible]
1.01	18.00	108	.04	.03	.01	48.	1.02	18.00	252	.47	.47	.00	8[illegible]
1.01	18.10	109	.02	.00	.00	46.	1.02	18.10	253	.06	.06	.00	7[illegible]

1.01	18.20	110	.00	.00	.00	42.	1.02	18.20	254	.04	.04	.00	7[illegible]

1.01	18.20	110	.00	.00	.00	42.	1.02	18.20	254	.04	.04	[illegible]	[illegible]
1.01	18.30	111	.00	.00	.00	36.	1.02	18.30	255	.04	.04	[illegible]	[illegible]
1.01	18.40	112	.00	.00	.00	29.	1.02	18.40	256	.04	.04	[illegible]	[illegible]
1.01	18.50	113	.00	.00	.00	22.	1.02	18.50	257	.04	.04	[illegible]	[illegible]
1.01	19.00	114	.00	.00	.00	16.	1.02	19.00	258	.04	.04	[illegible]	[illegible]
1.01	19.10	115	.00	.00	.00	12.	1.02	19.10	259	.04	.04	[illegible]	[illegible]
1.01	19.20	116	.00	.00	.00	10.	1.02	19.20	260	.04	.04	[illegible]	[illegible]
1.01	19.30	117	.00	.00	.00	8.	1.02	19.30	261	.04	.04	[illegible]	[illegible]
1.01	19.40	118	.00	.00	.00	7.	1.02	19.40	262	.04	.04	[illegible]	111.
1.01	19.50	119	.00	.00	.00	6.	1.02	19.50	263	.04	.04	[illegible]	[illegible]
1.01	20.00	120	.00	.00	.00	5.	1.02	20.00	264	.04	.04	[illegible]	[illegible]
1.01	20.10	121	.00	.00	.00	5.	1.02	20.10	265	.04	.04	[illegible]	[illegible]
1.01	20.20	122	.00	.00	.00	5.	1.02	20.20	266	.04	.04	[illegible]	75.
1.01	20.30	123	.00	.00	.00	4.	1.02	20.30	267	.04	.04	[illegible]	71.
1.01	20.40	124	.00	.00	.00	4.	1.02	20.40	268	.04	.04	[illegible]	[illegible]
1.01	20.50	125	.00	.00	.00	4.	1.02	20.50	269	.04	.04	[illegible]	[illegible]
1.01	21.00	126	.00	.00	.00	4.	1.02	21.00	270	.04	.04	[illegible]	[illegible]
1.01	21.10	127	.00	.00	.00	4.	1.02	21.10	271	.04	.04	[illegible]	[illegible]
1.01	21.20	128	.00	.00	.00	4.	1.02	21.20	272	.04	.04	[illegible]	[illegible]
1.01	21.30	129	.00	.00	.00	4.	1.02	21.30	273	.04	[illegible]	[illegible]	[illegible]
1.01	21.40	130	.00	.00	.00	4.	1.02	21.40	274	.04	[illegible]	[illegible]	[illegible]
1.01	21.50	131	.00	.00	.00	4.	1.02	21.50	275	.04	.04	[illegible]	[illegible]
1.01	22.00	132	.00	.00	.00	4.	1.02	22.00	276	.04	.04	[illegible]	[illegible]
1.01	22.10	133	.00	.00	.00	4.	1.02	22.10	277	.04	.04	[illegible]	[illegible]
1.01	22.20	134	.00	.00	.00	4.	1.02	22.20	278	.04	.04	[illegible]	[illegible]
1.01	22.30	135	.00	.00	.00	4.	1.02	22.30	279	.04	.04	[illegible]	[illegible]
1.01	22.40	136	.00	.00	.00	4.	1.02	22.40	280	.04	.04	[illegible]	[illegible]
1.01	22.50	137	.00	.00	.00	4.	1.02	22.50	281	.04	.04	[illegible]	[illegible]
1.01	23.00	138	.00	.00	.00	4.	1.02	23.00	282	.04	.04	[illegible]	[illegible]
1.01	23.10	139	.00	.00	.00	4.	1.02	23.10	283	.04	.04	[illegible]	[illegible]
1.01	23.20	140	.00	.00	.00	4.	1.02	23.20	284	.04	.04	[illegible]	[illegible]
1.01	23.30	141	.00	.00	.00	4.	1.02	23.30	285	.04	.04	[illegible]	[illegible]
1.01	23.40	142	.00	.00	.00	4.	1.02	23.40	286	.04	.04	[illegible]	[illegible]
1.01	23.50	143	.00	.00	.00	4.	1.02	23.50	287	.04	.04	[illegible]	[illegible]
1.02	.00	144	.00	.00	.00	4.	1.03	.00	288	.04	.04	[illegible]	[illegible]

SUM 35.28 31.75 [illegible] [illegible]
([illegible])([illegible])([illegible])(1448.45)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2421.	1050.	342.	178.	51115.
CMS	69.	30.	10.	5.	1448.
INCHES		24.43	31.85	33.03	33.03
MM		620.50	808.96	838.96	838.96
AC-FT		521.	679.	704.	704.
THOUS CU M		643.	838.	869.	869.

HYDROGRAPH AT STA HEAD FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]

0.	0.	0.	0.	0.	0.	0.	[illegible]	[illegible]	[illegible]

4.	4.	4.	4.	5.	7.	11.	16.	[illegible]	[illegible]
28.	31.	32.	33.	34.	34.	35.	[illegible]	[illegible]	[illegible]
36.	36.	36.	36.	36.	36.	36.	[illegible]	[illegible]	[illegible]
37.	37.	37.	37.	37.	37.	37.	37.	[illegible]	[illegible]
41.	50.	70.	94.	118.	139.	159.	167.	173.	176.
179.	182.	185.	186.	188.	189.	190.	191.	[illegible]	[illegible]
191.	193.	194.	194.	195.	195.	195.	[illegible]	[illegible]	[illegible]
197.	197.	197.	197.	198.	198.	207.	227.	246.	[illegible]
463.	504.	550.	588.	626.	667.	694.	719.	741.	767.
802.	841.	878.	908.	928.	949.	1013.	1251.	1474.	2167.
2421.	2379.	2337.	1805.	1525.	1337.	1205.	1101.	1012.	935.
873.	826.	779.	711.	605.	488.	372.	275.	267.	167.
132.	111.	96.	86.	79.	75.	71.	69.	67.	66.
66.	65.	65.	65.	65.	65.	65.	65.	65.	65.
65.	65.	65.	65.	65.	65.	65.	65.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2421.	1050.	342.	176.	[illegible]
CMS	69.	30.	10.	5.	1448.
INCHES		24.43	31.65	33.03	33.03
MM		620.50	803.96	838.96	838.96
AC-FT		521.	679.	704.	704.
THOUS CU M		643.	838.	869.	869.

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HYDROGRAPH ROUTING

ROUTE HYDROGRAPHS PAST DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
.0	.000	.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	.000	.000	.000	-530.	-1

STAGE	530.00	531.00	532.00	533.00	534.00	535.86	538.00	[illegible]	545.00	[illegible]
FLOW	.00	5.00	14.00	26.00	37.00	43.00	57.00	60.00	77.00	[illegible]

SURFACE AREA=	0.	3.	8.	14.	25.	35.	48.
CAPACITY=	0.	8.	115.	226.	421.	721.	1134.
ELEVATION=	492.	500.	520.	530.	540.	550.	560.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
530.0	.0	.0	.0	.0	.0	.0	.0

DAM DATA

DAM DATA

TOPEL	COQD	EXPD	DAMWID
535.8	.0	.0	0.

CREST LENGTH AT OR BELOW	0.	50.	147.	250.	332.	366.	427.	460.
ELEVATION	535.7	535.8	536.4	537.6	539.4	540.4	542.7	545.0

STATION   DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDIN

OUTFLOW

0.	0.	0.	0.	0.	0.	[illegible]	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	[illegible]	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	[illegible]
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	4.	4.	4.	4.
4.	4.	4.	5.	5.	5.	6.	6.	7.	7.
8.	9.	9.	10.	10.	11.	12.	13.	14.	[illegible]
17.	20.	22.	23.	25.	26.	26.	27.	27.	[illegible]
28.	28.	29.	29.	29.	29.	29.	29.	29.	29.
29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
28.	28.	28.	28.	28.	27.	27.	27.	[illegible]	[illegible]
27.	27.	27.	27.	26.	26.	26.	26.		

STORAGE

226.	226.	226.	226.	226.	226.	226.	226.	[illegible]	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	[illegible]	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	226.	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	226.	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	[illegible]	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	226.	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	226.	[illegible]
226.	226.	226.	226.	226.	226.	226.	226.	226.	[illegible]
226.	226.	226.	226.	227.	227.	227.	227.	227.	[illegible]
227.	227.	227.	227.	227.	227.	227.	227.	[illegible]	[illegible]
228.	228.	228.	228.	228.	228.	228.	228.	228.	228.
228.	228.	228.	228.	228.	228.	228.	228.	228.	228.

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	530.00	530.00	535.80
STORAGE	226.	226.	327.
OUTFLOW	0.	0.	45.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	535.89	.09	282.	29.	.00	[illegible]	[illegible]
.15	535.31	.30	311.	59.	.00	41.69	.00
.20	536.20	.40	335.	110.	1.67	41.50	.00
.25	536.57	.77	342.	237.	4.17	41.50	[illegible]
.30	536.87	1.07	346.	449.	5.83	40.[illegible]	[illegible]
.35	537.11	1.31	354.	657.	6.50	40.67	[illegible]
.40	537.31	1.51	358.	832.	7.17	40.50	.00
.50	537.56	1.76	364.	1101.	9.00	40.50	.00
1.00	538.39	2.59	382.	2788.	12.00	40.33	.00

OPIN

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
   1            A1      MISSOURI DAM INSPECTIONS
   2            A2      HOLTS LAKE
   3            A3      100 YEAR STORM
   4            B    288      0     10      0      0      0      0      0      0      0
   5            B1     1
   6            K            HEAD                                          1
   7            K1      CALCULATE INFLOW HYDROGRAPH TO LAKE
   8            M      2        20.4                        1.
   9            O    288   8.782                     RA 8   1.33
  10            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  11            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  12            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  13            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  14            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  15            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  16            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  17            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  18            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  19            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  20            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  21            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  22            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  23            O1  .008   .008   .008   .008   .008   .008   .008   .008   .008   .008
  24            O1  .008   .008   .008   .008   .011   .011   .011   .011   .011   .011
  25            O1  .011   .011   .011   .011   .011   .011   .011   .011   .011   .011
  26            O1  .011   .011   .011   .011   .011   .011   .011   .011   .011   .011
  27            O1  .011   .011   .011   .011   .011   .011   .011   .011   .011   .011
  28            O1  .029   .029   .029   .029   .029   .029   .029   .029   .029   .029
  29            O1  .029   .029   .029   .029   .029   .029   .029   .029   .029   .029
  30            O1  .029   .029   .029   .029   .029   .029   .029   .029   .029   .029
  31            O1  .029   .029   .029   .029   .029   .029   .056   .056   .056   .056
  32            O1  .056   .056   .056   .056   .056   .059   .059   .059   .131   .131
  33            O1  .131   .305   .307   .665  1.410   .577   .306   .131   .131   .131
  34            O1  .059   .059   .059   .056   .056   .056   .056   .056   .056   .056
  35            O1  .056   .056   .011   .011   .011   .011   .011   .011   .011   .011
  36            O1  .011   .011   .011   .011   .011   .011   .011   .011   .011   .011
  37            O1  .011   .011   .011   .011   .011   .011   .011   .011   .011   .011
  38            O1  .011   .011   .011   .011   .011   .011   .011   .011
  39            T                                                  -1-70.
  40            W2      1.0
  41            X               1.
  42            K      1      DAM                                     1
  43            K1      ROUTE HYDROGRAPH PAST DAM
  44            Y                                1      1
  45            Y1     1                               -530.             -1
  46            Y4530.  531.   532.   533.   534.   535.8  536.   540.   545.   550.
  47            Y50.     5.    16.    26.    33.    43.    53.    60.    77.    90.
  48            SA0.    3.1    8.0   14.5   24.9   35.2   47.7
  49            SE492.  503.   520.   530.   540.   550.   560.
  50            $$530.
```



```
  51            $$535.8
```

```
S1          SD535.8
S2          SLQ.    50.   147.   250.   332.   386.   427.   480.
S3          SV535.7 535.8 536.4 537.6 539.4 540.4 542.7 545.
S4          K     99
S5          A
S6          A
S7          A
S8          A
S9          A
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT HEAD
ROUTE HYDROGRAPH TO DAM
END OF NETWORK

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80

MISSOURI DAM INSPECTIONS
HOLTS LAKE
100 YEAR STORM

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			3	0	0	0			

SUB-AREA RUNOFF COMPUTATION

CALCULATE INFLOW HYDROGRAPH TO LAKE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
HEAD	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	.40	.00	.40	1.00	.000	0	0	0

PRECIP DATA

NP	STORM	DAJ	DAK
288	8.79	.00	.00

PRECIP PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.03	.03	.03	.03	.06	.06	.06	.06

.06	.06	.06	.06	.06	.06	.06	.06	.13	.13
.13	.30	.31	.69	1.41	.58	.31	.13	.13	.13
.06	.06	.06	.06	.06	.06	.06	.06	.06	.06
.06	.06	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01		

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	.00	.00	1.00	.00	.00	1.00	-1.00	-70.00	.00	.00

CURVE NO = -70.00 WETNESS = -1.00 EFFECT CN = 70.00

UNIT HYDROGRAPH DATA

TC= .00 LAG= 1.00

RECESSION DATA

STRTQ= .00 QRCSN= .00 RTIOR= 1.00

UNIT HYDROGRAPH 32 END OF PERIOD ORDINATES, TC= .00 HOURS, LAG= 1.00 VOL= 1.00

12.	36.	71.	122.	160.	177.	177.	162.	141.	115.
87.	65.	50.	40.	31.	24.	19.	15.	11.	9.
7.	5.	4.	3.	3.	2.	2.	1.	1.	1.
0.	0.								

END-OF-PERIOD FLOW

PO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	PO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.01	.00	.01	0.	1.02	.10	145	.01	.00	.01	1.
1.01	.20	2	.01	.00	.01	0.	1.02	.20	146	.01	.00	.01	1.
1.01	.30	3	.01	.00	.01	0.	1.02	.30	147	.01	.00	.01	1.
1.01	.40	4	.01	.00	.01	0.	1.02	.40	148	.01	.00	.01	2.
1.01	.50	5	.01	.00	.01	0.	1.02	.50	149	.01	.00	.01	2.
1.01	1.00	6	.01	.00	.01	0.	1.02	1.00	150	.01	.00	.01	2.
1.01	1.10	7	.01	.00	.01	0.	1.02	1.10	151	.01	.00	.01	2.
1.01	1.20	8	.01	.00	.01	0.	1.02	1.20	152	.01	.00	.01	2.
1.01	1.30	9	.01	.00	.01	0.	1.02	1.30	153	.01	.00	.01	2.
1.01	1.40	10	.01	.00	.01	0.	1.02	1.40	154	.01	.00	.01	2.
1.01	1.50	11	.01	.00	.01	0.	1.02	1.50	155	.01	.00	.01	2.
1.01	2.00	12	.01	.00	.01	0.	1.02	2.00	156	.01	.00	.01	2.
1.01	2.10	13	.01	.00	.01	0.	1.02	2.10	157	.01	.00	.01	2.
1.01	2.20	14	.01	.00	.01	0.	1.02	2.20	158	.01	.00	.01	3.
1.01	2.30	15	.01	.00	.01	0.	1.02	2.30	159	.01	.00	.01	3.
1.01	2.40	16	.01	.00	.01	0.	1.02	2.40	160	.01	.00	.01	3.
1.01	2.50	17	.01	.00	.01	0.	1.02	2.50	161	.01	.00	.01	3.
1.01	3.00	18	.01	.00	.01	0.	1.02	3.00	162	.01	.00	.01	3.
1.01	3.10	19	.01	.00	.01	0.	1.02	3.10	163	.01	.00	.01	3.
1.01	3.20	20	.01	.00	.01	0.	1.02	3.20	164	.01	.00	.01	3.
1.01	3.30	21	.01	.00	.01	0.	1.02	3.30	165	.01	.00	.01	3.
1.01	3.40	22	.01	.00	.01	0.	1.02	3.40	166	.01	.00	.01	3.
1.01	3.50	23	.01	.00	.01	0.	1.02	3.50	167	.01	.00	.01	3.
1.01	4.00	24	.01	.00	.01	0.	1.02	4.00	168	.01	.00	.01	3.
1.01	4.10	25	.01	.00	.01	0.	1.02	4.10	169	.01	.00	.01	3.
1.01	4.20	26	.01	.00	.01	0.	1.02	4.20	170	.01	.00	.01	3.
1.01	4.30	27	.01	.00	.01	0.	1.02	4.30	171	.01	.00	.01	3.

1.01	4.40	28	.01	.00	.01	0.	1.02	4.40	172	.01	.00	.01	4.

FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM M21/02-1V TIME 09:55:29 CASE

1.01	4.40	28	.01	.00	.01	0.	1.02	4.40	172	.01	.00	.01	4.
1.01	4.50	29	.01	.00	.01	0.	1.02	4.50	173	.01	.00	.01	4.
1.01	4.60	30	.01	.00	.01	0.	1.02	4.60	174	.01	.00	.01	4.
1.01	4.70	31	.01	.00	.01	0.	1.02	4.70	175	.01	.00	.01	4.
1.01	4.80	32	.01	.00	.01	0.	1.02	4.80	176	.01	.00	.01	4.
1.01	4.90	33	.01	.00	.01	0.	1.02	4.90	177	.01	.00	.01	4.
1.01	5.00	34	.01	.00	.01	0.	1.02	5.00	178	.01	.00	.01	4.
1.01	5.10	35	.01	.00	.01	0.	1.02	5.10	179	.01	.00	.01	4.
1.01	5.20	36	.01	.00	.01	0.	1.02	5.20	180	.01	.00	.01	4.
1.01	5.30	37	.01	.00	.01	0.	1.02	5.30	181	.01	.00	.01	4.
1.01	5.40	38	.01	.00	.01	0.	1.02	5.40	182	.01	.00	.02	4.
1.01	5.50	39	.01	.00	.01	0.	1.02	5.50	183	.01	.01	.02	5.
1.01	5.60	40	.01	.00	.01	0.	1.02	5.60	184	.01	.01	.02	5.
1.01	6.50	41	.01	.00	.01	0.	1.02	6.50	185	.01	.01	.02	6.
1.01	7.00	42	.01	.00	.01	0.	1.02	7.00	186	.01	.01	.02	7.
1.01	7.10	43	.01	.00	.01	0.	1.02	7.10	187	.01	.01	.02	8.
1.01	7.20	44	.01	.00	.01	0.	1.02	7.20	188	.01	.01	.02	9.
1.01	7.30	45	.01	.00	.01	0.	1.02	7.30	189	.01	.01	.02	10.
1.01	7.40	46	.01	.00	.01	0.	1.02	7.40	190	.01	.01	.02	11.
1.01	7.50	47	.01	.00	.01	0.	1.02	7.50	191	.01	.01	.02	12.
1.01	8.00	48	.01	.00	.01	0.	1.02	8.00	192	.01	.01	.02	13.
1.01	8.10	49	.01	.00	.01	0.	1.02	8.10	193	.01	.01	.02	14.
1.01	8.20	50	.01	.00	.01	0.	1.02	8.20	194	.01	.01	.02	15.
1.01	8.30	51	.01	.00	.01	0.	1.02	8.30	195	.01	.01	.02	16.
1.01	8.40	52	.01	.00	.01	0.	1.02	8.40	196	.01	.01	.02	16.
1.01	8.50	53	.01	.00	.01	0.	1.02	8.50	197	.01	.01	.02	17.
1.01	9.00	54	.01	.00	.01	0.	1.02	9.00	198	.01	.01	.02	18.
1.01	9.10	55	.01	.00	.01	0.	1.02	9.10	199	.01	.01	.02	19.
1.01	9.20	56	.01	.00	.01	0.	1.02	9.20	200	.01	.01	.02	20.
1.01	9.30	57	.01	.00	.01	0.	1.02	9.30	201	.01	.01	.02	21.
1.01	9.40	58	.01	.00	.01	0.	1.02	9.40	202	.01	.01	.02	22.
1.01	9.50	59	.01	.00	.01	0.	1.02	9.50	203	.01	.01	.02	23.
1.01	10.00	60	.01	.00	.01	0.	1.02	10.00	204	.01	.01	.02	24.
1.01	10.10	61	.01	.00	.01	0.	1.02	10.10	205	.01	.01	.02	25.
1.01	10.20	62	.01	.00	.01	0.	1.02	10.20	206	.01	.01	.02	26.
1.01	10.30	63	.01	.00	.01	0.	1.02	10.30	207	.01	.01	.02	27.
1.01	10.40	64	.01	.00	.01	0.	1.02	10.40	208	.01	.01	.02	28.
1.01	10.50	65	.01	.00	.01	0.	1.02	10.50	209	.01	.01	.02	29.
1.01	11.00	66	.01	.00	.01	0.	1.02	11.00	210	.01	.01	.02	30.
1.01	11.10	67	.01	.00	.01	0.	1.02	11.10	211	.01	.01	.02	31.
1.01	11.20	68	.01	.00	.01	0.	1.02	11.20	212	.01	.01	.02	32.
1.01	11.30	69	.01	.00	.01	0.	1.02	11.30	213	.01	.01	.02	33.
1.01	11.40	70	.01	.00	.01	0.	1.02	11.40	214	.01	.01	.02	34.
1.01	11.50	71	.01	.00	.01	0.	1.02	11.50	215	.01	.01	.01	35.
1.01	12.00	72	.01	.00	.01	0.	1.02	12.00	216	.01	.01	.01	36.
1.01	12.10	73	.01	.00	.01	0.	1.02	12.10	217	.06	.03	.02	37.
1.01	12.20	74	.01	.00	.01	0.	1.02	12.20	218	.06	.03	.02	38.
1.01	12.30	75	.01	.00	.01	0.	1.02	12.30	219	.06	.03	.02	39.
1.01	12.40	76	.01	.00	.01	0.	1.02	12.40	220	.06	.03	.02	40.
1.01	12.50	77	.01	.00	.01	0.	1.02	12.50	221	.06	.03	.02	41.
1.01	13.00	78	.01	.00	.01	0.	1.02	13.00	222	.06	.03	.02	42.
1.01	13.10	79	.01	.00	.01	0.	1.02	13.10	223	.06	.03	.02	43.
1.01	13.20	80	.01	.00	.01	0.	1.02	13.20	224	.06	.03	.02	44.
1.01	13.30	81	.01	.00	.01	0.	1.02	13.30	225	.06	.03	.02	45.
1.01	13.40	82	.01	.00	.01	0.	1.02	13.40	226	.06	.03	.02	46.
1.01	13.50	83	.01	.00	.01	0.	1.02	13.50	227	.06	.03	.02	46.

FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM M21/02-1V TIME 09:55:29 CASE

FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM H21/02-1V TIME 09:55:20 CASE

1.01	16.00	R6	.01	.00	.01	0.	1.02	16.00	228	.04	.04	.02	64.
1.01	16.10	R5	.01	.00	.01	0.	1.02	16.10	229	.13	.[illegible]	.05	64.
1.01	16.20	R6	.01	.00	.01	0.	1.02	16.20	230	.17	.[illegible]	.05	64.
1.01	16.30	R7	.01	.00	.01	0.	1.02	16.30	231	.13	.08	.03	54.
1.01	16.40	R8	.01	.00	.01	0.	1.02	16.40	232	.11	.10	.03	46.
1.01	16.50	R9	.01	.00	.01	0.	1.02	16.50	233	.11	.11	.03	39.
1.01	17.00	90	.01	.00	.01	0.	1.02	17.00	234	.09	.10	.03	34.
1.01	17.10	91	.01	.00	.01	0.	1.02	17.10	235	1.42	1.10	.31	1[illegible].
1.01	17.20	92	.01	.00	.01	0.	1.02	17.20	236	.58	.48	.10	601.
1.01	17.30	93	.01	.00	.01	0.	1.02	17.30	237	.31	.26	.05	289.
1.01	17.40	94	.01	.00	.01	0.	1.02	17.40	238	.13	.11	.02	276.
1.01	17.50	95	.01	.00	.01	0.	1.02	17.50	239	.13	.11	.02	271.
1.01	18.00	96	.01	.00	.01	0.	1.02	18.00	240	.13	.11	.02	6[illegible].
1.01	18.10	97	.01	.00	.01	0.	1.02	18.10	241	.08	.07	.01	3[illegible].
1.01	18.20	98	.01	.00	.01	0.	1.02	18.20	242	.06	.05	.01	478.
1.01	18.30	99	.01	.00	.01	0.	1.02	18.30	243	.06	.05	.01	456.
1.01	18.40	100	.01	.00	.01	0.	1.02	18.40	244	.06	.05	.01	379.
1.01	18.50	101	.01	.00	.01	0.	1.02	18.50	245	.06	.05	.01	319.
1.01	19.00	102	.01	.00	.01	0.	1.02	19.00	246	.06	.05	.01	2[illegible].
1.01	19.10	103	.01	.00	.01	0.	1.02	19.10	247	.06	.05	.01	22[illegible].
1.01	19.20	104	.01	.00	.01	0.	1.02	19.20	248	.06	.05	.01	196.
1.01	19.30	105	.01	.00	.01	0.	1.02	19.30	249	.06	.05	.01	169.
1.01	19.40	106	.01	.00	.01	0.	1.02	19.40	250	.06	.05	.01	145.
1.01	19.50	107	.01	.00	.01	0.	1.02	19.50	251	.06	.05	.01	12[illegible].
1.01	20.00	108	.01	.00	.01	0.	1.02	20.00	252	.06	.05	.01	11[illegible].
1.01	20.10	109	.01	.00	.01	0.	1.02	20.10	253	.01	.01	.00	105.
1.01	20.20	110	.01	.00	.01	0.	1.02	20.20	254	.01	.01	.00	100.
1.01	20.30	111	.01	.00	.01	0.	1.02	20.30	255	.01	.01	.00	91.
1.01	20.40	112	.01	.00	.01	0.	1.02	20.40	256	.01	.01	.00	82.
1.01	20.50	113	.01	.00	.01	0.	1.02	20.50	257	.01	.01	.00	72.
1.01	21.00	114	.01	.00	.01	0.	1.02	21.00	258	.01	.01	.00	65.
1.01	21.10	115	.01	.00	.01	0.	1.02	21.10	259	.01	.01	.00	59.
1.01	21.20	116	.01	.00	.01	0.	1.02	21.20	260	.01	.01	.00	46.
1.01	21.30	117	.01	.00	.01	0.	1.02	21.30	261	.01	.01	.00	39.
1.01	21.40	118	.01	.00	.01	0.	1.02	21.40	262	.01	.01	.00	33.
1.01	21.50	119	.01	.00	.01	0.	1.02	21.50	263	.01	.01	.00	29.
1.01	22.00	120	.01	.00	.01	0.	1.02	22.00	264	.01	.01	.00	26.
1.01	22.10	121	.01	.00	.01	0.	1.02	22.10	265	.01	.01	.00	22.
1.01	22.20	122	.01	.00	.01	0.	1.02	22.20	266	.01	.01	.00	21.
1.01	22.30	123	.01	.00	.01	0.	1.02	22.30	267	.01	.01	.00	19.
1.01	22.40	124	.01	.00	.01	0.	1.02	22.40	268	.01	.01	.00	18.
1.01	22.50	125	.01	.00	.01	0.	1.02	22.50	269	.01	.01	.00	16.
1.01	23.00	126	.01	.00	.01	1.	1.02	23.00	270	.01	.01	.00	17.
1.01	23.10	127	.01	.00	.01	1.	1.02	23.10	271	.01	.01	.00	16.
1.01	23.20	128	.01	.00	.01	1.	1.02	23.20	272	.01	.01	.00	16.
1.01	23.30	129	.01	.00	.01	1.	1.02	23.30	273	.01	.01	.00	16.
1.01	23.40	130	.01	.00	.01	1.	1.02	23.40	274	.01	.01	.00	16.
1.01	23.50	131	.01	.00	.01	1.	1.02	23.50	275	.01	.01	.00	15.
1.01	24.00	132	.01	.00	.01	1.	1.02	24.00	276	.01	.01	.00	15.
1.01	24.10	133	.01	.00	.01	1.	1.02	24.10	277	.01	.01	.00	15.
1.01	24.20	134	.01	.00	.01	1.	1.02	24.20	278	.01	.01	.00	15.
1.01	24.30	135	.01	.00	.01	1.	1.02	24.30	279	.01	.01	.00	15.
1.01	24.40	136	.01	.00	.01	1.	1.02	24.40	280	.01	.01	.00	15.
1.01	24.50	137	.01	.00	.01	1.	1.02	24.50	281	.01	.01	.00	15.
1.01	25.00	138	.01	.00	.01	1.	1.02	25.00	282	.01	.01	.00	15.
1.01	25.10	139	.01	.00	.01	1.	1.02	25.10	283	.01	.01	.00	15.

FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM H21/02-1V TIME 09:55:20 CASE

1.01	25.20	140	.01	.00	.01	1.	1.02	25.20	284	.01	.01	.00	15.

1.01	23.30	140	.01	.00	.01	1.	1.02	23.20	284	.01	.01	.00	15.
1.01	23.40	141	.01	.00	.01	1.	1.02	23.30	285	.01	.01	.00	15.
1.01	23.40	142	.01	.00	.01	1.	1.02	23.40	286	.01	.01	.00	15.
1.01	23.50	143	.01	.00	.01	1.	1.02	23.50	287	.01	.01	.00	15.
1.02	.00	144	.01	.00	.01	1.	1.02	.00	288	.01	.01	.00	15.
									SUM	8.78	5.96	3.64	7640.
										(223.0)(151.3)(92.3)(194.0)			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	502.	196.	56.	27.	7647.
CMS	14.	5.	2.	1.	217.
INCHES		4.19	5.05	5.07	5.07
MM		106.43	128.37	128.70	128.70
AC-FT		89.	108.	108.	108.
THOUS CU M		110.	133.	133.	133.

****

HYDROGRAPH ROUTING

ROUTE HYDROGRAPH PAST BAR

ISTAO	ICOPP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
BAR	1	0	0	0	0	1	0	0

ROUTING DATA

IOPT	IPPP	LSTR
0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	.000	.000	.000	-530.	-1

STAGE	530.00	531.00	532.00	533.00	534.00	535.80	538.00	540.00	545.00	550.00
FLOW	.00	5.00	14.00	26.00	33.00	42.00	53.00	60.00	77.00	90.00
SURFACE AREA=	0.	3.	8.	14.	25.	35.	48.			
CAPACITY=	0.	8.	115.	226.	421.	721.	1134.			
ELEVATION=	492.	500.	520.	530.	540.	550.	569.			

CREL	SPWID	COOL	EXPW	ELEVL	COOL	CAREA	EXPL
530.0	.0	.0	.0	.0	.0	.0	.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
535.8	.0	.0	0.

CREST LENGTH=	0.	50.	147.	250.	332.	364.	427.	480.
AT OR BELOW ELEVATION.	535.7	535.8	536.4	537.4	539.4	540.4	542.7	545.0

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	530.00	530.00	535.80
	STORAGE	226.	226.	327.
	OUTFLOW	0.	0.	45.

	RATIO OF PMF	PEAKFLOW RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	PEAKFLOW STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
100 YEAR	1.00	535.19	.00	314.	40.	.00	43.50	.00

END

APPENDIX B

GROUTING OPERATIONS

Holts Lake

October 27, 1980

J. F. Davies
Burton Duenke Construction
Senior Vice President
P. O. Box 12878
St. Louis, MO 63141

Dear Mr. Davies:

On 20 October 1980, I met with Mr. Don Ramsey and Dave Taylor of Test Drilling Services and they gave me a preview on their grouting program on the west Chesterfield Lake. I have a copy of their report of hole location, overburden depth, grout intake, etc.

It appears that most of the grout intake was at or just below the bottom of the lake with respect to elevation. The larger grout intake zones appear to be horizontal bedding planes which are probably the feeder systems that we discussed on numerous occasions. Any particular vertical fracture zone in these areas could also be the outlet for lake water into the hill to the spring system. Grouting of the horizontal feeder system, however, may be as or more important than locating the specific area where the water leaves the valley. There does not appear to be any way that the specific zone where the water leaves the valley can be located. The grouting of the feeder systems may well have taken care of the problem, at least in the area that they grouted.

I checked the spring down at Caulks Creek and it was still flowing a small quantity of water. The water was very clear and not cloudy as it has been everytime I've checked it in the past. In addition, the orifice of the spring now has at least three points where the spring water is emerging. I don't know what the significance of this is.

At Don Ramsey's suggestion, it is recommended that no more grouting can be done between station 2+55 north and the dam until sufficient rainfall or pumping has occurred to raise the water level of the lake so it can be observed for stability. It is entirely possible that the zones that they have grouted will have reduced the outflow of water sufficient to where it is not a problem any more. I believe the zones that have been grouted have been sufficiently grouted to where they should no longer present a problem. If the lake level arises considerably and then drops, I would recommend that the grouting program continue between station 2+55 and the dam.

Past conversations suggested that if the zone where water leaves the valley could be located that it be grouted above the water line in the area of the

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P. O. Box 250 Rolla, Missouri 65401 (314) 364-1752

Joseph P. Teasdale Governor
Ted A. Lasfer Director

Division of Geology and Land Survey
Wallace B. Howe Director

blacktop road. In reviewing the information on the depth of overburden, it appears that the soil thickness is sufficient in the lake to where grouting on the present shoreline should be effective. At this time, I do not believe that grouting at a higher elevation is necessary.

In summary, I recommend that we wait until the lake can be observed as to whether it is still leaking before more grouting is done.

Yours truly,

Thomas J. Dean, Geologist
Engineering Geology Section
Geology & Land Survey

cc: Don Ramsey

END

DATE
FILMED

12-81

DTIC